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SMALL-AREA STATISTICS PAPERS
SERIES GE-41, NO. 3

STATISTICAL ISSUES IN ALLOCATING FEDERAL FUNDS AND ESTIMATION OF LOCAL GOVERNMENT FINANCES

Papers Presented at the Conference on Small-Area Statistics

American Statistical Association
Boston, Mass.
August 25-26, 1976

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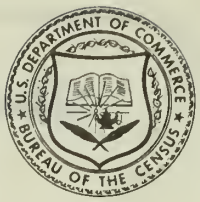

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PREFACE

This report contains the papers presented at the Conference on Small-Area Statistics in Boston, Mass. on August 25 and 26, 1976, during two sessions of the annual meeting of the American Statistical Association (ASA).

The first session of the 1976 Conference concerned *Issues in the Development of Statistics for Allocating Federal Funds* and was jointly sponsored by the ASA Social Statistics Section, and the ASA Committee on Small-Area Statistics. Daniel B. Levine, Associate Director for Demographic Fields, Bureau of the Census, organized and chaired this session. The speakers were Thomas B. Jabine, Wray Smith, and Joseph W. Duncan.

The second session dealt primarily with *Estimation of Local Government Finances* and was jointly sponsored by the ASA Business and Economic Statistics Section, and the ASA Committee on Small-Area Statistics. Harold M. Hochman, Professor of Economics, City University of New York, chaired this session. The speakers were Ben - chieh Liu, Allen M. Wyse, and Terry H. Morlan with David Harrison, Jr., as discussant.

This report was organized and prepared under the direction of Robert C. Klove, Geographic Research Advisor, Statistical Research Division, and Conrad J. Thoren, Geographer, Geography Division.

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Issues in the Development of Statistics for Allocating Federal Funds

INTRODUCTION

Daniel B. Levine
Bureau of the Census

For many years it has been the practice at the annual meetings of the American Statistical Association (ASA) to devote a small number of sessions to the unique problems of small-area statistics. The 1976 annual meetings were no exception.

The session jointly sponsored by the Committee on Small-Area Statistics and the Business and Economic Statistics section of the American Statistical Association dealt with "Issues in the Development of Statistics for Allocating Federal Funds." There can be no question that the recent "explosion" in legislation which results in the allocation of Federal funds to State and local governments made this an extremely appropriate and important topic for discussion. To place the issue in perspective, the volume of Federal funds distributed to State and local governments in fiscal year 1975 approximated $45 billion.

The three papers presented at the session fully met the challenge of the topic and proved provocative and enlightening.

The paper by Mr. Jabine dealt with the difficult problem of attempting to meet the requirement of "equity" in the allocation of funds based on sample data.

Mr. Smith's paper, on the other hand, considered the difficult and delicate problem of attempting to develop possible guidelines on allocation of funds from the point of view of the necessary statistical adjustment of data to compensate for biases.

Finally, Mr. Duncan dealt with the broad policy framework and addressed statistical policy issues related to formula allocations to State and local governments.

Equity in the Allocation of Funds Based on Sample Data

Thomas B. Jabine
Social Security Administration

INTRODUCTION

"Equity" is used in the title in the sense of fairness or impartiality. In a fair game everyone plays under the same rules. Thus, in the allocation of Federal funds, whether to political subdivisions or directly to individuals, it is considered desirable that there exist a set of objective rules or criteria to decide who gets how much.

Ideally, application of the allocation rules should be based on available accurate information. In practice this is usually not the case. The classifications and quantities used in allocation formulas may be subject to measurement error, and application of decision rules by different individuals, or even the same individual at different times, may have different results.

This paper deals with two aspects of equity in allocation processes which are subject to error. Part I, discusses the effects of sampling error on procedures for allocation of funds to political subdivisions through formula grants. Particular attention is given to the issue of equity in the allocation, among political subdivisions, of a sample to be used to estimate values used in the allocation formula.

Part II, considers questions of equity in situations where benefits are awarded to individuals on the basis of certain eligibility criteria, and the process of determining eligibility is subject to error. Considering each decision on a claim for benefits as a sample of one out of many possible decisions, a model is developed which sheds light on what happens when denied applicants are allowed to appeal through one or more stages of review.

Part I. ALLOCATIONS OF FUNDS TO POLITICAL SUBDIVISIONS BASED ON SAMPLE DATA

Federal funds are often allocated to political subdivisions on the basis of formulas using population counts and other statistics, such as numbers of school age children, per capita incomes, or unemployment rates. Complete count data are not available for some of these items and for others are available only once every 10 years from the Decennial Census. Hence, for allocations to reflect the current situation, estimates based on sample data must often be used in the allocation formulas.

Because the allocations are affected by sampling error, some individuals will receive less than they would have in the absence of sampling error and others will receive more. This consideration leads to a question of equity or fairness to individuals, namely, how should resources for the collection of sample data be allocated among the political subdivisions to which the funds are to be distributed?

In this section, a simple funds allocation model is used to examine the effects of alternative criteria for sample allocation. The alternatives considered are:

1. A sample allocation which insures equal treatment for eligible individuals in all political subdivisions.
2. A sample allocation which minimizes, for all eligible individuals, the sum of squared differences between actual and "correct" per capita allocations, but does not necessarily insure equal treatment for individuals in different political subdivisions.

These alternative criteria lead to different allocations of the resources available for collecting sample data. The first alternative leads to approximately equal sample sizes for all States. The second alternative leads to allocation in proportion to the square root of total population.

Model and Assumptions

It is postulated that the Federal government is to allocate a fixed amount of money among the States, in proportion to the number of residents of each State who have some specified characteristic, such as being of school age. Since current counts of persons with the specified characteristic are not available, a sample survey will be taken to obtain estimates. A fixed amount of money is available for the survey.

The problem is how to allocate the resources available for the sample among the States. The following assumptions are made:[1]

1. Sampling error is the only source of error in the allocations.
2. Counts, or good estimates of total population, are available for all States.
3. A simple random sample of persons will be used in each State.
4. The only cost attached to the gathering of the sample information in each State is a fixed cost per individual in the sample.
5. Within each State, the amount allocated will be shared equally by each person with the specified characteristic.

Notation—

N_i = population of the i^{th} State

$N = \sum_i N_i$

n_i = sample size for the i^{th} State

$n = \sum_i n_i$ (fixed)

Π_i = proportion of persons with the specified characteristic in the i^{th} State

p_i = proportion of persons with the specified characteristic in the sample for the i^{th} State

D = total amount of money to be allocated

[1] Most of the assumptions are not met in real allocation problems, but can probably be relaxed or removed without appreciably changing the main result.

The allocation formula is—

$$\hat{D}_i = \frac{N_i\ p_i}{\sum_i N_i\ p_i}\ D \qquad (1)$$

where $\hat{D}_i$ is the amount to be allocated to the i^{th} State and

$$\sum_i \hat{D}_i = D$$

Within a State, the amount to go to each individual, either directly or indirectly, through provision of benefits or services is—

$$\hat{D}_{ij} = \frac{\hat{D}_i}{N_i\ \Pi_i} = \frac{p_i}{\Pi_i} \cdot \frac{D}{\sum_i N_i\ p_i} \quad \text{(see assumption 5)} \qquad (2)$$

The difference between the actual allocation to the j^{th} person in the i^{th} State and the "correct" allocation, which would have been made if complete counts were available, is given by—

$$\begin{aligned} \Delta_{ij} &= \hat{D}_{ij} - D_{ij} \\ &= D\ \left[\frac{p_i}{\Pi_i \sum_i N_i\ p_i} - \frac{1}{\sum N_i\ \Pi_i}\right] \end{aligned} \qquad (3)$$

Since $\Delta_{ij} = \Delta_i$ for all j, we will drop the j subscript.

Alternatives will be evaluated by examining their effects on Δ_i^2. This gives equal importance to errors in either direction, and gives greater weight to extreme departures from the "correct" value.

First Criterion—Equal Treatment to Residents of All States

To achieve this objective, we require that the *expected value* of Δ_i^2 be the same for every State.

We have

$$\begin{aligned} E\ \Delta_i^2 &= D^2\ E\ \left[\frac{p_i}{\Pi_i \sum_i N_i\ p_i} - \frac{1}{\sum_i N_i\ \Pi_i}\right]^2 \\ &= \frac{A}{\Pi_i^2}\ E\ \left[p_i\ \frac{\sum_i N_i\ \Pi_i}{\sum_i N_i\ p_i} - \Pi_i\right]^2 \end{aligned} \qquad (4)$$

where $$A = \frac{D^2}{\left(\sum_i N_i\ \Pi_i\right)^2}$$

Since the factor $\dfrac{\sum_i N_i\ \Pi_i}{\sum_i N_i\ p_i}$ is the same for all States, and close to 1, we may expect that—

1. It will have only a minor effect on $E\ \Delta_i^2$.

2. It will have, at most, a second-order effect on the *allocation* of the sample between States.

Thus, we can say—

$$\begin{aligned} E\ \Delta_i^2 &\doteq \frac{A}{\Pi_i^2}\ \sigma_{p_i}^2 \\ &\doteq A\ \frac{N_i - n_i}{N_i}\ \frac{(1 - \Pi_i)}{n_i\ \Pi_i} \end{aligned} \qquad (5)$$

if we assume sampling without replacement.

To fulfill our criterion, we must have: $E\ \Delta_i^2 = C$

which requires $$n_i = \frac{A(1 - \Pi_i)}{C\ \Pi_i + \frac{A(1-\Pi_i)}{N_i}} \qquad (6)$$

and $$\lim_{N_i \to \infty} n_i = \frac{A(1 - \Pi_i)}{C\ \Pi_i} \qquad (7)$$

The interpretation of these results is that, to treat residents of all States equally, we must estimate the number, or proportion, of eligible persons in each State with the same *relative* reliability.

This in turn implies that we should select approximately the same size sample from each State. Departures from equality in sample size will depend on—

1. The finite population correction.
2. Advance information about approximate values of Π_i which are not the same for all States.

Departures from equality in sample size can be substantial if the range of assumed initial values of the Π_i's is large, especially if the smallest value is close to zero or the largest close to one. Using the subscripts "S" and "L" to denote the States with the smallest and largest assumed Π_i's, respectively, the ratio of the indicated sample sizes for the two States is (assuming $N_i \gg n_i$)

$$R_2 = \frac{n_S}{n_L} = \frac{1-\Pi_S}{1-\Pi_L} \cdot \frac{\Pi_L}{\Pi_S} \qquad (8)$$

For example, with $\Pi_L = 0.100$ and $\Pi_S = 0.005$, we have $R = 22.1$. The total populations of the two States do not enter into this formulation. Thus we could have the rather surprising result that a small State with a small proportion of persons in the target population could require a sample over 20 times as large as that needed for a large State with a considerably larger proportion of its residents in the target population.

Second Criterion—Minimizing the Expected Value of the Total Squared Difference Over All States

Another possible objective would be to minimize the expected value of $\Theta = \sum_i \sum_j \Delta_{ij}^2$

What does this imply in terms of sample allocation?

$$\Theta = \sum_i \sum_j D^2 \left[\frac{p_i}{\Pi_i \sum_i N_i p_i} - \frac{1}{\sum_i N_i \Pi_i}\right]^2 \tag{9}$$

$$= \frac{D^2}{(\sum_i N_i \Pi_i)^2} \sum_i \frac{N_i}{\Pi_i} \left[p_i \frac{\sum_i N_i \Pi_i}{\sum_i N_i p_i} - \Pi_i\right]^2$$

and $$E(\Theta) = B \sum_i \frac{N_i}{\Pi_i} E \left[p_i \frac{\sum_i N_i \Pi_i}{\sum_i N_i p_i} - \Pi_i\right]^2 \tag{10}$$

where $$B = \frac{D^2}{(\sum_i N_i \Pi_i)^2}$$

Making the same assumption as before:

$$E(\Theta) \doteq B \sum_i \frac{N_i}{\Pi_i} \sigma^2_{p_i}$$

$$\doteq B \sum_i \frac{N_i}{\Pi_i} \frac{N_i - n_i}{N_i} \frac{\Pi_i (1 - \Pi_i)}{n_i} \tag{11}$$

$$= B \sum_i \frac{N_i - n_i}{n_i} (1 - \Pi_i)$$

To minimize $E(\Theta)$, subject to the constraint that $\sum_i n_i = n$, we have:

$$n_i = n \frac{[N_i(1-\Pi_i)]^{\frac{1}{2}}}{\sum_i [N_i(1-\Pi_i)]^{\frac{1}{2}}} \tag{12}$$

As opposed to the first ciriterion, which called for approximately the same sample size in every State, this criterion calls for allocating the sample in proportion to the square root of the resident population, with departures from this allocation if there is advance information on approximate values of the Π_i's. The effect on the allocation of differing Π_i's is much less than when the first criterion is used. Using the same notation as before, we have:

$$R_2 = \frac{nS}{n_L} = \frac{[N_S (1-\Pi_S)]^{\frac{1}{2}}}{[N_L (1-\Pi_L)]^{\frac{1}{2}}} \tag{13}$$

Using the same example as before, if we assume $N_S = N_L$, $\Pi_L = 0.100$ and $\Pi_S = 0.005$, we have $R = 1.05$.

Comparison of the Two Criteria

For a fixed total sample of size n, the second criterion minimizes the expected value of (θ), the total squared difference for all eligible persons in all States. How much larger will the expected value of (θ) be if we allocate the sample of size "n" according to the first criterion, which assures equal treatment for eligible persons in every State?

To simplify the comparison, first, let us consider the case where $\Pi_1 = \Pi_2 = \cdots = \Pi_s$

where s = the number of States and $N_i >> n_i$ for all i.

Under these conditions we have:

$$E(\Theta) \doteq B \sum_i \frac{N_i}{\Pi} \cdot \frac{\Pi(1-\Pi)}{n_i}$$

$$= B (1-\Pi) \sum_i \frac{N_i}{n_i} \tag{14}$$

For the first criterion, we have:

$$E \Delta_i^2 \doteq \frac{A(1-\Pi)}{n_i \Pi} = C$$

$$\text{so } n_i = \frac{A(1-\Pi)}{C \Pi}$$

and $$\sum_i^s n_i = n = \frac{s A(1-\Pi)}{C \Pi}$$

so that $$C = \frac{s A(1-\Pi)}{n \Pi}$$

and $$n_i = \frac{n}{s}$$

i.e., we should have the same size sample in each State.

Substituting in $E(\theta)$, we have for criterion one—

$$E(\Theta)_{min} = B(1-\Pi) \sum_i \frac{N_i}{n/s}$$

$$= \frac{B(1-\Pi)\, N\, s}{n} \tag{15}$$

For the second criterion, we find that the expected value of (θ)

is minimized when $n_i = n \frac{N_i^{\frac{1}{2}}}{\sum_i N_i^{\frac{1}{2}}}$ for all i.

and the minimum value of $E(\theta)$ is

$$E(\Theta)_{min} = B(1-\Pi) \sum_i \frac{N_i}{n} \frac{\sum N_i^{\frac{1}{2}}}{N_i^{\frac{1}{2}}}$$

$$= \frac{B(1-\Pi)}{n} \left[\sum_i N_i^{\frac{1}{2}}\right]^2 \tag{16}$$

We may now examine the ratio, R of $E(\theta)$ for criteria one and two

$$R_1 = \frac{E_1(\Theta)}{E_2(\Theta)} = \frac{Ns}{[\sum_i N_i^{\frac{1}{2}}]^2} \tag{17}$$

and if we let $N_i = k_i N$

where k_i is the proportion of the total population in the i^{th} State, we have:

$$R_1 = \frac{Ns}{[N^{\frac{1}{2}} \sum_i k_i^{\frac{1}{2}}]^2} = \frac{s}{[\sum_i k_i^{\frac{1}{2}}]^2} \tag{18}$$

Using the 1970 census population figures for the 50 States and the District of Columbia, we have:

$$R_1 = \frac{51}{6.3207^2} = 1.277$$

so that the expected value of (θ), the sum of the squared differences when criterion one is used exceeds its minimum value by 27.7 percent.

On the other hand, if we compare $E\Delta_i^2$ for the smallest and largest States when criterion two is used, we have:

$$R_2 = \frac{A(1-\Pi)/n_S\ \Pi}{A(1-\Pi)/n_L\ \Pi} = \frac{n_L}{n_S} \qquad (19)$$

$$= \frac{N_L^{\frac{1}{2}}}{N_S^{\frac{1}{2}}} = \frac{k_L^{\frac{1}{2}}}{k_S^{\frac{1}{2}}}$$

Using the same data as before, we have:

$$R_2 = \left[\frac{.098188}{.001476}\right]^{\frac{1}{2}} = 8.156$$

i.e., for the eligible person in Alaska, the expected value of the squared difference between the correct allocation and the sample-based allocation is slightly over eight times as great as it is for the eligible person in California.

If we drop the assumption of equal Π_i's, we find that—

$$R_1 = \frac{\sum_i^S N_i\ \Pi_i \sum_i^S \frac{(1-\Pi_i)}{\Pi_i}}{\{\sum_i^S [N_i(1-\Pi_i)]^{\frac{1}{2}}\}^2} \qquad (20)$$

Suppose, for example, that we were planning to use a sample to estimate the number of persons currently living in poverty in each of the 50 States and the District of Columbia. Again using the 1970 census population figures for the N_i's, and taking the census figures on percent of persons below low income level in 1969 for the Π_i's, we find $R_1 = 1.373$.

To determine the States with the smallest and largest values of $E\Delta_i^2$ when criterion two is used, we must identify the States which have the smallest and largest values of the quantity.

$$\phi = \frac{(1-\Pi_i)}{\Pi_i\ [N_i(1-\Pi_i)]^{\frac{1}{2}}} \qquad (21)$$

If we use the subscripts "S" and "L" to denote these two States, we have—

$$R_2 = \frac{\phi_L}{\phi_S} \qquad (22)$$

In the present illustration, we find that the two States are Nevada and Texas, and that $R_2 = 10.459$.

PART II. ALLOCATIONS OF FUNDS TO INDIVIDUALS IN PROCESSES SUBJECT TO MEASUREMENT ERROR

In this section, a model is developed for use in examining issues of equity in the allocation of funds directly to individuals, for example, in various income maintenance programs, where individuals apply for benefits and a decision is made in each case as to the individual's eligibility to receive benefits.

Particular attention will be given to the effects of errors in these decisions, and to the results of permitting one or more stages of appeal to denied claimants.

What is the relevance of such a discussion in a paper dealing with the allocation of resources based on *sample* data? It is true that a separate decision is made based on the available information for each claim or application. However, it is very helpful in studying the process to treat that single decision as being a random sample of one from a population of possible decisions for that claim—all made under the same rules and general conditions. This view of the situation is, of course, the basis for most theories which attempt to deal with measurement and response errors.[2]

If the decision rules were completely objective and the decision process were perfectly executed, we would always arrive at the same decision—allow or deny—for a particular claim. It should come as no surprise that this is not the case.

The conditions, including the complexity of statutory program requirements, that lead to decisional errors were eloquently described by a high-ranking Department of Health, Education, and Welfare (HEW) official in recent testimony before the Subcommittee on Oversight of the House Ways and Means Committee.[3]

Specific evidence of variability (and by implication, error) in decisions is available from the results of various quality assurance and evaluation activities applied to income maintenance programs. An interesting recent study was the one carried out by the General Accounting Office (GAO) in which a sample of claims for social security disability benefits was adjudicated independently by 10 States.[4] While GAO did not analyze the results in depth, they made the source data available to the Social Security Administration (SSA), and the data have been used to estimate (subject to the limitations of the original study design) measures of variability for this particular claims adjudication process.

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[2] Hansen, M.H.; W.N. Hurwitz, and M.A. Bershad, "Measurement Errors in Censuses and Surveys." Bulletin of the International Statistical Institute, Vol. XXXVIII: Part II, pp. 359-374, Tokyo, 1961.

[3] Morrill, William A., Assistant Secretary for Planning and Evaluation, (HEW), statement before the Subcommittee on Oversight, Committee on Ways and Means, U.S. House of Representatives, May 3, 1976.

[4] Ahart, Gregory J., General Accounting Office, "State Agency Operations for Determining Disability under Social Security Programs and Improvements Needed in Efforts to Rehabilitate Social Security Disability Insurance Beneficiaries," statement before the Subcommittee on Social Security, Committee on Ways and Means, U.S. House of Representatives, February 3, 1976.

The Model—Assumptions and Notation[5]

Given the possibility of multiple decisions for a particular claim, one can talk about the probability that a particular claim will be correctly decided, and it is possible to develop a model based on expected outcomes for defined groups of claims.

The model presented here is not an exact representation of any claims adjudication process; however, some of its features apply to the adjudication of social security disability claims. The motivation for its construction is to assist in better understanding of that and other similar claims adjudication processes.

The model describes a process in which individuals apply for benefits—some eligible and some ineligible. Some are allowed and some denied. Decisions may be correct or incorrect.[6] Persons whose claims are denied may, at their option, appeal the result through one or more stages of review. It is assumed that there are no changes in the "true" status of the claim throughout the decision process either eligible or ineligible.

Let N = number of claimants
and N_e = number of claimants who are in fact eligible for benefits
N_i = number of claimants who are ineligible for benefits

Thus $N_e + N_i = N$

Let s = number of stages, including initial review and all appeals stages, at which decisions may be made.
and let j = 1,2, ... , s be a subscript representing a particular decision stage.
Let p_{ej} = probability that an eligible claimant will be correctly classified as eligible at the j^{th} decision stage.
and p_{ij} = probability that an ineligible claimant will be correctly classified as ineligible at the j^{th} decision stage.
Let Π_{ej} = probability that an eligible claimant who is denied at stage j will appeal to the next stage.
and Π_{ij} = probability that an ineligible claimant denied at stage j will appeal to the next stage.

Development of the Model

In the analysis of this adjudication process, it is of interest to know to what extent eligible persons are denied benefits and ineligible persons are allowed benefits. The expected number of allowances for eligible claimants takes the form,

$$E(A_e) = N_e p_{e_1} + N_e (1 - p_{e_1}) \Pi_{e_1} p_{e2} + N_e (1 - p_{e_1}) \Pi_{e_1} (1 - p_{e2}) \Pi_{e2} p_{e3} + \ldots \quad (23)$$

and the expected number of allowances for *ineligible* claimants is—

$$E(A_i) = N_i (1 - p_{i1}) + N_i p_{i1} \Pi_{i1} (1 - p_{i2}) + N_i p_{i1} \Pi_{i1} p_{i2} \Pi_{i2} (1 - p_{i3}) + \ldots \quad (24)$$

Analogous expressions can be developed for $E(D_e)$ and $E(D_i)$ and the expected numbers of denials for eligible and ineligible claimants, respectively. These quantities may be displayed in a 2 X 2 table.

Correct classification	Total	Actual outcome	
		Allow	Deny
Total	N	E(A)	E(D)
Eligible	N_e	$E(A_e)$	$E(D_e)$
Ineligible	N_i	$E(A_i)$	$E(D_i)$

The table provides the basis for several measures of the accuracy of the adjudication process outcomes, e.g., the gross error rate:

$$\frac{[E(A_i) + E(D_e)] \times 100}{N}$$

Ratio of allowances to eligibles:

$$\frac{E(A)}{N_e}$$

Proportion of eligibles allowed:

$$\frac{E(A_e)}{N_e}$$

Proportion of ineligibles denied:

$$\frac{E(D_i)}{N_i}$$

A Simplified Version of the Model

To better understand the properties of the system, it is helpful to make some simplifying assumptions. Consider an adjudication process with three stages of appeal for claims

[5] The reader is cautioned that certain symbols already used in Part I are used with different meanings in Part II.

[6] It is assumed, for the purposes of this model, there exists some means by which a single "correct" decision can be arrived at in every case. In practice, there may very well be borderline cases in which the decision calls for considerable exercise of judgment and experienced adjudicators will disagree as to the proper outcome. In fact, it may even be argued that two adjudicators who reach opposite conclusions based on the same facts are both arriving at "correct" decisions.

denied at the immediately preceding stage, and suppose that $P_{ej} = P$ and $P_{ij} = P$ for all J, that is, the probability of a correct decision is the same at all stages for both eligible and ineligible cases. Suppose, that $\Pi_{ej} = \Pi$ and $\Pi_{ij} = \Pi$ for all j, that is, the probability of a claimant appealing a decision to deny benefits is the same at all stages for eligible and ineligible cases. With these assumptions, we find that:

$$E(A_e) = N_e \, p \sum_{j=1}^{4} (1 - p)^{j-1} \, \Pi^{j-1} \qquad (25)$$

and

$$E(A_i) = N_i \, (1 - p) \sum_{j=1}^{4} p^{j-1} \, \Pi^{j-1} \qquad (26)$$

where each of the terms of the summations represents the allowances at the corresponding decision stage.

If the process were terminated at the end of the initial adjudication stage, the expected total number of allowances, sum of the first terms of assumptions (25) and (26), would be $E(A) = N_e + (N_i - N_e)(1 - P)$ and there would be no net error if $N_i = N_e$. There would be an excess of allowances, that is, a ratio of allowances to eligibles greater than one, if $N_i > N_e$, and vice versa.

To see what happens as the claims proceed through the appeals stages, let us examine a numerical example with—

$$N_e = N_i = 100{,}000$$
$$P = .95, \Pi = .50$$

The results are shown in table 1. There is a moderate increase in the gross error rate, proportion of claims eventually decided incorrectly, after the first appeal. The ratio of allowances to eligibles is 1,000 after the initial decision stage, indicating zero *net* error. However, it increases substantially as a result of the first appeal, and gradually thereafter. After the third appeal, allowances exceed eligibles by 6.5 percent.

The most striking result is that, with the parameter values assumed in this example, the second and third appeals do very little to help eligibles who were incorrectly denied at earlier stages. The main effect of these appeals stages is to increase the number of allowances to persons who are ineligible.

Some Properties of the Model

The following observations can be made about the relations between parameter values and outcomes:

1. Other things being equal, the ratio of allowances to eligibles will increase as the appeal rates, Π_{ej} and Π_{ij}, increase. Thus, recent increases in appeal rates of denied claims for social security disability benefits may explain a substantial proportion of the overall increase in allowances. In the illustration from the previous section, using an appeals rate of 0.25 in place of 0.50, the ratio of allowances to eligibles is only 1.027 after the third appeal stage. In other words, with the actual number of eligibles remaining constant, an increase in appeals rates from 25 percent to 50 percent causes a 3.7 percent increase in the number of allowances.

2. It seems reasonable to assume that denied eligibles will appeal at a higher rate than denied ineligibles. If such is the case, a higher proportion of allowances in the various appeals stages will be to eligible persons, and the net error, as indicated by the ratio of allowances to eligibles, will be smaller. For example, in the illustration, if we let $\Pi_e = 0.50$ and $\Pi_i = 0.10$, the ratio of allowances to eligibles after the first appeal is 1.028 and by the end of the third appeal it has only increased to 1.030.

3. An increase in the number of ineligibles applying for benefits, with the number of eligibles held constant, leads to an increase in the number of allowances. Even if the value of "p" is higher and "Π" lower for the additional applicants, some increase will occur. For example, in the illustrations shown in table 1, adding 50,000 claims by ineligibles with p, the probability of a correct decision being 0.97, and Π, the probability of an appeal to the next stage being 0.30, would add an expected 2,101 allowances, raising the ratio of allowances to eligibles from 1.065 to 1.086.

4. The illustrations so far have assumed the same probability of a correct decision for eligibles and ineligibles at every stage. A bias or net error in favor of allowances would, of course, increase the ratio of allowances to eligibles, and vice versa.

5. On an a priori basis it is difficult to say what trend one might expect in the p_{ej}'s and p_{ij}'s as the claims proceed through the several stages of appeal. On one hand, we might expect decisions at successive stages to be made by more experienced persons on the basis of more complete evidence. On the other hand, one would expect a screening-out of clearcut denials to occur at each stage, so that the remaining claims would be more difficult to decide.

Equity Implications

Finally, what does this model tell us about equity in the decision process and what does it suggest about possiblities for improvement? Equity in this model involves a balancing of two objectives. Equity to eligible claimants require that all or virtually all of them be allowed benefits, preferably, without having to go through lengthy appeals. On the other hand, equity to the general public requires that they not be obliged to pay the cost of benefits awarded to substantial numbers of ineligible persons.

A point which seems obvious, but is not often discussed, is that the eligible claimant who is denied benefits initially will only receive benefits if he decides to appeal his claim. Unfortunately for him, as a denied claimant he has no way of knowing whether he is, in fact, eligible for benefits. It may very well be that eligible claimants denied initially—appeal at a higher rate than ineligible claimants. However, there are many other variables which affect a claimant's decision whether or

Table 1. Numerical Illustration of the Simplified Model

($N_e = N_i = 100{,}000$, $P = 0.95$, $\Pi = 0.50$)

Decision stage	Eligibles (N_e = 100,000)					Ineligibles (N_i = 100,000)					Gross error rate through this stage (percent)	Ratio of allowances to eligibles through this stage
	Number allowed		Number denied		Cumulative proportion allowed	Number allowed		Number denied		Cumulative proportion allowed		
	This stage	Cumulative	This stage	Through this stage[1]		This stage	Cumulative	This stage	Through this stage[1]			
Initial	95,000	95,000	5,000	5,000	0.950	5,000	5,000	95,000	95,000	0.950	5.00	1.000
1st appeal	2,375	97,375	125	2,625	0.974	2,375	7,375	45,125	92,625	0.074	5.00	1.048
2nd appeal ...	60	97,435	3	2,565	0.974	1,128	8,503	21,435	91,497	0.085	5.53	1.059
3rd appeal ...	1	97,436	—	2,564	0.974	536	9,039	10,181	90,961	0.090	5.80	1.065

[1] Persons denied at current stage plus those not appealing denials at preceding stages.

not to appeal, including psychological or attitudinal traits such as aggressiveness and acceptance of authority. Thus, it is certain that by no means, all eligible claimants who are denied initially will appeal.

At the same time, since most of the eligible claimants are allowed benefits initially, it is likely that the ratio of ineligibles to eligibles among the claimants will increase rapidly from one appeals stage to another (see table 1). Thus, at the final (3d) appeal stage in the illustration, the claimants appealing include only 2 eligibles (actually an expected 1.5 persons) and 10,718 ineligibles, so even though only a small proportion of ineligibles is allowed benefits, virtually all of the allowances at this stage are to ineligibles.[7]

What could be done to design a more equitable claims adjudications process, taking into account the costs of reviewing and deciding claims at various stages?

One way of making the process more equitable would be to have more claims correctly handled at the intial stage. How could this be done? In the physical sciences it is common practice to make a series of observations to arrive at estimates of critical values. Thus, instead of taking a sample of one from an infinite universe of possible observations, a larger sample is used in order to limit the effects of random error in the measurement process.

Similar schemes could be used for initial claims adjudication. For example, it would be possible to have three claims adjudicators review the evidence and arrive at independent decisions to allow or deny, and then to accept the majority decision. Alternatively, there could be two independent decisions. If they agreed, the decision would be accepted; if not, the claim could be subjected to some kind of refereeing procedure for a final decision.

[7] The model discussed here assumes that the claimant's true status—eligible or ineligible—does not change during the claims adjudication process. In real life changes do occur. To the extent that changes from ineligible to eligible predominate, the illustration overstates the number of incorrect allowances resulting from the three stages of appeal.

It has been assumed so far that the probability of a correct decision depends only on whether or not the claimant is eligible, and on the stage of the review process. However, intuition (and some evidence) tells us that not all claims by eligible or ineligible persons at a particular stage are equally error-prone. Thus, it may be possible to make the process just described more efficient, while retaining the equity features, by starting the initial claims review with a screening process in which, based on a limited review, cases would be classified into three groups, that is, (1) high probability of allowance, (2) high probability of denial, and (3) outcome uncertain (this group could include cases for which insufficient evidence has been obtained). Then the cases in groups one and two would be treated by the standard approach, that is, decision by a single adjudicator, while those in group three would be decided by one of the multiexaminer procedure described above.

Clearly, the unit cost of processing initial claims would be higher for such a procedure. However, the increased costs at this stage might be offset by:

a) A decline in the number of allowances to ineligibles.

b) Cutting back on the number of stages of appeal allowed claimants. (One should be careful in doing this as not to eliminate the possibility of submitting a *new* claim for someone whose situation has changed significantly.)

This discussion should not be interpreted as a proposal to restructure any particular claims adjudication process. However, the analysis does suggest that some of the processes may not be optimally structured, and there may be cases where equity can be improved and total program costs reduced simultaneously. To do this would require, (1) designing the process with explicit recognition that decision errors do occur, and (2), conducting studies to provide reasonably accurate estimates of the parameters of the model. Replication studies in which claims are independently decided by more than one adjudicator are especially valuable for this purpose.

On Allocation Schemes and the Interface Between Statistics and Policy

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Perhaps a better title for this paper would be, "Between Statistics and Politics," but I won't have too much to say directly about politics, although that is an ever-present consideration in understanding allocation problems. The originally scheduled panelist is a senior member of the staff of the Congressional Budget Office, and would no doubt be in a good position to assess the interplay of statistical data, allocation rules, and political considerations from the perspective of the budget process. The context in which I am addressing Federal allocations is somewhat different.

There is an active interagency committee, known as the Interagency Committee on Statistical Methodology, which like a number of other useful Federal statistical committees functions under the auspices of the Office of Management and Budget. One of its subcommittees is dealing with "possible [statistical] guidelines on allocation of funds and statistical adjustment of data to compensate for biases." It is the work of that subcommittee over the past several months which provides the perspective for this paper.

A number of the ideas set forth here arose in conversations with members of that subcommittee, for which some acknowledgment is given. I do think that questions of theory and method are directly relevant to the purposes of this panel session. Therefore, I want to try to call attention—further attention, really—to some outstanding technical research issues that emerge under current statutory provisions for grant formulas. Some of these observations arose out of a series of five case studies that our subcommittee examined, and I will identify them although I am not directing my comments to any specific Federal program. They are General Revenue Sharing, the Comprehensive Employment and Training Act (CETA) programs, Title I of the Elementary and Secondary Education Act (ESEA), Aid for Dependent Children (AFDC), and Community Development Block Grants (CDBG). These programs are five of the ten largest Federal grant-in-aid programs that either use formulas or some allocation rule. For example, AFDC involves a matching rate which has many properties in common with allocation formulas for distributing Federal funds. The case studies have provided us with a certain amount of clinical material, and although we are not yet through assessing it, many of the thoughts in this paper have been stimulated by that ongoing review.

For example, there are some participants in the ASA Conferences on Small-Area Statistics who have contributed to the five-foot shelf of studies on General Revenue Sharing. The National Science Foundation and other organizations have sponsored a good deal of research and evaluation on formula problems arising in that program. In view of the very large amounts of money involved in the program, it has seemed quite worthwhile to examine a number of formula problems in considerable detail, including, especially those relating to equity considerations. Studies are still going on to try to understand all the important consequences for State and local governments in the operation of the General Revenue Sharing allocation rule—which is, in fact, a kind of iterative algorithm.

It is not our purpose in this review to concentrate on the technical details of allocation formulas. Rather, we need to try to identify some of the elements that must be dealt with if the statistical and other implications of various types of formulas are to be understood. I believe it is important to recognize the complex nature of the problems presented and the limitations of our currently available tools in dealing with the special problems that arise.

In my judgment we need to stimulate response to the development of extensions of existing statistical theory (not only statistical theory, but also economic and political theory) in directions that offer promise of making many of the allocation problems a good deal more tractable than they are at present. It seems useful to take, as a point of departure, the recent conference paper by Mr. I.R. Savage[1] entitled "Cost-Benefit Analysis of Demographic Data," in which he discussed the economic, political, and social aspects of the use of demographic data in governmental activities—all in relation to the kinds of contributions that might be expected from statistical theory in locating problems and in encouraging workers in the operational data system to formulate problems.

The issues discussed by Mr. Savage should be reviewed by anyone who would like to make a comprehensive attack on any subset of problems presented by allocation formulas, the data to drive them, or their distributional consequences. It should be recognized that the identification and characterization of key technical problem areas relating to allocation research issues also involves the following elements: (a) *Equity* considerations both ethical and analytical, some of which have been dealt with in the panel paper by Mr. Jabine,[2] which are typically both subtle and complex and carry the statistician into perilous areas of inquiry; (b) *structural* aspects of the computation formula or algorithm (including additive, multiplicative, iterative, and mixed structures), noting that some so-called allocation formulas do not have a closed-form representation; (c) the *nature of the data* required to drive the formula—where does it come from, what is its quality?, etc.; (d) the implicit or explicit performance criterion for the particular Federal program—its *objective function* or, perhaps, the appropriate welfare function—hopefully derivable from the stated legislative intent of the program; (e) presence or absence of *constraints* such as floors or ceilings (or "hold harmless" provisions, such as a specified percentage of the previous year's allocation), which may, as a result of the way they are defined, be themselves time-varying or serially-correlated random elements in the allocation scheme; and (f) other *specification* or

[1] Savage, I.R. (1975) "Cost-Benefit Analysis of Demographic Data," Supplement to Advances in Applied Probability, Vol. 7., pp. 62-71.

[2] Jabine, T.J. (1976). "Equity in the Allocation of Funds Based on Sample Data." (Paper presented in this report)

modeling problems, such as "How well does a particular formula capture the real-world dynamics it is presumably designed to address?"

It is possible to adopt a helpful paradigm for allocation formula research in which the allocation is taken to be some function of *needs*, *capability*, and *effort*, each of which is assumed to be at least approximately observed at the State or local level. However, there are serious definition and interaction problems imbedded in this seemingly plausible phrase. A more rigorous analysis of complexity must be sought, perhaps along the lines suggested by Mr. van Emden,[3] if we are to take proper account of such things as the interaction between a particular Federal program and other programs affecting the same State or locality. The fact that a need may appropriately have different components in two geographic areas, that taxable real estate and personal income may not give an adequate basis for capability, that local tax revenue effort may need to be analyzed in terms of the purposes to which the revenues are applied, etc.

There are other elements of allocation formula problems. For example, the sensitivity of a particular formula to small, perhaps irrelevant, changes in the specified data overtime. For many programs, a slowly varying level of funds allocation may be a desirable feature to be sought in building a suitable allocation formula. You want the formula to respond fast enough, but not too fast, to changing conditions. The local government must be given some reasonable stable assurance of the general level of Federal funding it is to receive in future fiscal periods, otherwise, local planning can easily become very chaotic and piecemeal.

Another important question is the transparency of an allocation formula—can it be understood? Can citizens understand it? Politicians? Statisticans? Some formulas we have examined in existing Federal programs deserve to be called opaque. Their behavior overtime cannot be simply explained and may even exhibit some surprising and unanticipated results.

It is not possible in this brief review paper to go into detail on any one of these research issues. However, it is important, to note some of the relevant methodological tools and relevant areas of substantive theory that need to be brought together if we are to achieve a coherent approach to allocation problems. First, we can register considerable agreement with Mr. Savage in his "working hypothesis...that the collection of the major statistical series and some of their important uses can be formulated as a statistical decision problem." That is, the statistical issues of allocation policy have imbedded in them the problem of "...how much data to collect and what kind of terminal losses to anticipate."

Mr. Jabine and others have considered a mean-squared error criterion in treating equity considerations that arise in both grant-in-aid programs to governmental units and programs with direct benefits to individuals. There are related problems of just how much to pay to improve the quality of the data used by a formula or group of formulas; for example, how much effort should go into trying to reduce the census undercount for certain population subgroups and what are the appropriate methods used to correct the undercounts that remain?

When is it appropriate to use a symmetric loss function, such as Mr. Jabine's quadratic loss function, and when should we use an asymmetric loss function, with different penalties for overshooting or undershooting the desired fair (but unknown) allocation level to a State or local government entity? These are only part of the technical issues. The statistician really needs to be told by the policymaker what class of loss function is required. The difficulty comes in the fact that we do not have a very adequate set of statistical and computational tools to work with any but the simplest departures from symmetry in our penalty functions. This area does belong on our research agenda, and is noted in Mr. Waud's 1976 article[4] on "Asymmetric Policymaker Utility Functions and Optimal Policy Under Uncertainty."

The problem areas we have been traversing are not fully described and certainly not exhausted by the kinds of characterizations that we have outlined above. To get some perspective on these many specific technical and normative issues it is helpful to go back to Mr. Arrow's 1951 monograph[5] on "Social Choice and Individual Values" and subsequent literature on social choice theory, voting behavior (and its paradoxes), measurement of social welfare, and a number of related topics.

In this connection we should mention Mr. Plott's 1973 article[6] entitled "Path Independence, Rationality, and Social Choice" and the references cited. We are not suggesting that statisticians get deeply involved in some complete axiomatic formulation involving possibility (or impossibility) theorems, but they should be aware that some of the statistical research issues of allocation formulas can be illuminated by theoretical principles from other fields. It is not necessary to point out that the whole complex web of individual preferences, subgroup choice, and national interest is much more than a statistical problem. The challenge here is to proceed from first principles and to end up doing some practical work of value for the policymaker.

At this point, the whole problem area sounds incredibly difficult and complicated, and I believe, it is inherently so. Nevertheless, it appears to be the case that research progress is possible. We do need some concerted technical effort and some better organizing principles—and quite a bit of luck—to put together the right kind of research and evaluation agenda. One of the initial difficulties that must be overcome is that very few applied research workers who are or might be drawn into working on allocation problems have the necessary knowledge and background to constitute anything approaching joint mastery of enough relevant theory and methods. A partial

[3] van Emden, M.H. (1971). The Analysis of Complexity. Mathematisone Centrum, Amsterdam. 86 pp.

[4] Waud, R.N. (1976). "Asymmetric Policymaker Utility Functions and Optimal Policy Under Uncertainty," Econometricia, Vol. 44, pp. 53-66.

[5] Arrow, K.J. (1951, 1963). Social Choice and Individual Values. John Wiley and Sons, Inc. New York.

[6] Plott, C.R. (1973). "Path Independence, Rationality, and Social Choice," Econometrica, Vol. 41, pp. 1075-1091.

listing of the areas of theory, methods, and applications that must be included in such a concerted research attack on allocation issues is set forth in the accompanying table.

Theory	Methods	Applications
Statistical decision	Iterative adjustment	Practical politics
Social choice	Nonlinear programming	Public administration
Welfare economics	Sensitivity analysis	Legislative apportionment
Control	Stochastic modeling	Income distribution
	Quality control	Poverty measurement
		Public finance

The relevance of each of these topics to formula research may be obvious enough, but the appropriate characterization of their interrelations is by no means trivial.

My own preliminary notions of some early steps that need to be taken toward getting it all together may be summarized in two distinct but related kinds of activity.

First, we need to develop soon some more or less respectable statistical methods, which will necessarily involve new approximation techniques, to describe and test resultant allocations, both under existing programs and for newly proposed programs, so that we can tell the consumer—whether citizen or policymaker—how good the description or test is. And this is where the problem comes in if we should need to use, for example, an asymmetric loss function. We typically will not have any satisfactory exact distribution theory to appeal to, we will be adopting some approximate measures which will have to be justified on both theoretical grounds and through simulation experiments, and then we will have to translate all of that effort into a set of statistical statements that may literally have to stand up in court.

Second, as an interim measure, we do need some standard practice statistical guidelines for policymakers and statisticians involved in constructing or revising allocation schemes for grant-in-aid programs. At the very least, such guidelines should warn practitioners away from some of the more dangerous practices with disagreeable consequences—as may be found in some existing formula programs. For example, under some circumstances such guidelines might advocate the use of a particular population or economic statistic that was neither the most recent nor the finest in geographic detail if it were to have other statistical properties, such as stability from one time period to the next or uniform quality across geographic areas, that were superior for the specific objectives of a Federal program and class of allocation formulas. The presence of such state-of-the-art guidelines might lead to a simplification and increase in the clarity of allocation schemes to be adopted in the future.

I wish to acknowledge that these remarks are based in part on discussions with Charles Troob as well as with Tore Dalenius, Maria Gonzales, Tom Jabine, Eli Marks, and the case study task leaders of the subcommittee cited above.

Statistical Policy Issues Related to Formula Allocations of Federal Funds to State and Local Governments

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The importance of this topic is highlighted by the following factors:

1. The volume of Federal funds distributed to States and local governments was about $49 billion[1] in Fiscal Year 1975.
2. The concepts of the new Federalism which were introduced several years ago are now an important part of our national attitude.

These distributions and concepts focus more responsibility at the local level. Both Congress and the current Administration through major programs ranging from revenue sharing to many special purpose grants have set in motion a national policy which is likely to continue for a number of years.

In dealing with these sizeable distributions and implementing this policy cost-effectiveness criteria tell us that money should go: (a) Where the most need exists, and (b) where programs will be best administered.

Further, we must consider equity in the distributions. From a policy perspective we want to assure the highest level of equity possible in the distribution of Federal funds and benefits.

Statistics have varying degrees of influence on these considerations:

1. The volume of dollars to be incorporated in the Federal budget is a fundamental *policy* decision and is generally not related to individual statistical series, except insofar as policy is developed by understanding the condition of the Nation as a whole.
2. The development of new Federalism and the assignment of responsibility to the local level of government means that more data are needed at lower levels of geographic detail. (This relaxes assumption 5 in Jabine's paper, amplifying the differences he noted on State versus national strategy.)
3. In defining needs—statistics are important for defining the size of the various groups, since programs are directed toward poor people, specific ethnic groups, particular training needs, etc., and it is essential to know the size and characteristics of these target groups.
4. Statistical series are not directly designed or useful in answering the question of where programs will be best administered although one may be able to establish so-called "indicators," such as local tax effort, to serve as a proxy for local concern or effort.
5. The relationship between statistics and equity is important when equity can be defined in measurable terms. Unfortunately, at present the concept of "equity" in the distribution of Federal benefits is not well defined in a generally accepted fashion. For example, income equity in relation to various Federal benefits probably means that we should measure income received in real terms. This requires that we know the specific pattern and cost of local purchases in relation to local income and we do not presently have a nationwide program for such measurement. Similarly, the definition of poverty might need to be adjusted for cost-of-living differentials in different areas of the country.

Hence, three general considerations for statistics emerge. They are: (a) Geographic detail, (b) socioeconomic details, and (c) equity.

Implications for Statistics

As we review the three points mentioned above, the implications for statistical data are:

Geographic detail.—The development of more geographic detail for statistical data series involves high cost efforts. Local area detail is primarily obtained from the decennial census. The current Administration presently supports the Senate Bill (S. 3688) which would authorize a mid-decade statistical effort. Such a statistical effort would provide a 5-year benchmark for many local areas receiving formula grant allocations. However, local area estimates from annual survey data would be virtually impossible to obtain because the costs of such data collection efforts would be intolerably high.

Annual State level estimates can be derived in some cases at reasonable costs. For example, the Current Population Survey in response to the CETA legislation was recently expanded to obtain annual unemployment rates of acceptable precision for all States. This survey also produces monthly estimates of unemployment for the Nation as a whole.

Often legislation drafted for a program involving allocation of Federal funds to local areas requires data at a level of geography which are not available on a current basis. To respond to the new legislation, statistical efforts are launched to try to comply with the requirements established. For example, the General Revenue Sharing legislation required data on population and per capita income for 39,000 governmental units. These data are available from the decennial census, but not for intercensal periods. In order to obtain such intercensal estimates the Office of Revenue Sharing commissioned the Census Bureau to derive such estimates. This project required a large new statistical effort which involved matching Internal Revenue Service tax records for 2 different years to obtain estimates of internal migration for very small geographic areas. Such a project illustrates the impact which legislation may have on statistical efforts.

[1] Special Analysis, Budget of the United States Government, Fiscal Year 1977.

Many politicians are most interested in "current data for my district" and as a result we are often faced with legislation which places impossible demands upon the statistical system.

Socioeconomic detail.—Many programs concerned with specific subgroups of the population require statistics for small target groups, such as the elderly, or the disabled. For example, the Survey of Income and Education's main goal was to estimate the number of children 5 years old to 17 years old in poverty families by State. Such statistics were required for allocation of Title I funds in the Elementary and Secondary Education Act of 1965, as amended in 1974. This survey was also used to identify population groups requiring bilingual education, handicapped population in need of special training, and persons receiving food stamps.

The problem of obtaining statistics for small socioeconomic groups is similar to the problem of obtaining statistics for small geographic areas. The cost of producing, on a current basis, statistical data for small areas or for small population groups is often prohibitively high. For some purposes, use of administrative data as proxies for the data required may produce adequate results; however, administrative data frequently cover only limited portions of the subgroups of interest.

Obviously, the demand for socioeconomic detail cross-classified by geographic detail compounds the problem and creates an additional set of demands upon statistical programs.

Equity.—To achieve equity in the allocation of Federal funds a basic consideration is the availability of *consistent* data. Office of Management and Budget (OMB) Circular No. A-46, Exhibit I establishes that the population data to be used for allocation of funds correspond to the estimates published by the Bureau of the Census in its P-25, Population Estimates and Projections and P-26, Federal-State Cooperative Program for Population Estimates series, except when decennial census data are more current. Exhibit V of Circular A-46 establishes that official estimates of labor force or unemployment are the ones published by the Bureau of Labor Statistics. These two standards tend to create consistency of population and labor force data.

To achieve equity in allocation of Federal funds to local areas one would have to evaluate for each area: (a) Its needs, (b) its resources, and (c) its capacity to implement an adequate program.

The objective would be for Federal allocations to be distributed proportionally to need in the local area, using local resources as available and using local capacity to administer the programs effectively.

Although equity is a goal for all Federal programs involving allocation of funds to local areas, Mr. Jabine has illustrated the difficulty of choosing the best equity criterion. Further, other considerations often affect the outcome. Legislation generally specifies allocation of funds based on specific formulas and data elements. Such specifications may be the result of political compromise rather than considerations of equity alone. In addition, many programs need a long lead time and, therefore, the stability of allocation of funds for more than 1 year is important. This factor is not always explicitly considered in drafting legislation.

The general statistical principles which should be followed are:

1. To assure equity, consistent data sets should be used for allocation.
2. Formulas should be simple and straightforward to insure that: (a) The data demands are reasonable, (b) their effects are easily understood, and (c) they are free from arbitrary constraints which may effect only limited subgroups.

Mr. Smith's paper noted the importance of these factors, however, (to use his terms) there is a conflict between easy understanding and the use of more sophisticated approaches such as asymmetric versus symmetric objective functions.

Subcommittee on Guidelines for Allocation of Funds

The Statistical Policy Division of the Office of Management and Budget is currently leading an effort to deal with some of these issues. A subcommittee of the Interagency Committee on Statistical Methodology of the Statistical Policy Division is addressing the issue of whether guidelines can be established on the allocation of Federal funds to State and local government. This subcommittee is studying 5 of the largest 10 grant-in-aid programs which use population and/or income data to allocate funds. These five case studies are being analyzed to determine type of formula used for distribution of funds, as well as the statistical series selected for these programs. The subcommittee will be preparing a report by January 1977. Today's discussion will be a helpful input into the subcommittee's review.

Estimation of Local Government Finances

Introduction

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There have been significant substantive advances in the theory of local public finance and the incorporation of the public sector in formal urban models during the last two decades. Many of the major contributions have been speculative and abstract, not only because theory has logical priority, but because it is difficult to define suitable data and testable hypotheses. Moreover, when benefits are communal (as they are, largely with government provision) and choices, though grounded in citizen preferences, are transmitted through a political rather than market processes, formal estimation becomes difficult, both to apply and interpret, and the gap between theory and reality widens.

The papers presented in this symposium, in different ways, contribute to reduction of this empirical gap. Mr. Morlan develops the demand components of a model of State and local expenditures, disaggregated by function and local employment. These estimates are to be used in projecting both short-run and long-run expenditure behavior, in the context of a broader and complementary inquiry into the sources of economic growth. Mr. Wyse examines, in a more intensive fashion, one particular factor in the local economic activity, the housing services component of the demand for local public services. Among other things, he inquires into the interface of the government and the private sector in the housing area, and examines their relationship within a model in which both the demand for housing and supply of housing are endogenous. Within a much more general frame of reference, Mr. Lee and Mr. Liu attempt to synthesize modern theories of regional growth, as driven by migration and local public finance, using the provision of health care and educational services to illustrate and test their argument.

While the three papers are quite different in their immediate focus, they share a deep concern with the empirical examination of well-specified behavioral hypotheses. Despite inevitable ambiguities, many inherent in their substantive concern with local public finance, all of the papers seem to succeed on this score. They leave us with a better quantitative understanding of the intricate relationships that comprise local public finance, and a clear indication of directions that might be taken in future research.

An Econometric Model of Metropolitan Growth With Endogenous Local Finances★

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INTRODUCTION

Both regional growth and local government finance have received enormous attention from economists. Conceptually, metropolitan growth theories fall into three broad categories based on their special emphasis on determinants: Some economists emphasize national forces, some stress internal structures and endowments, and still others stress both. However, the effects of local government finance or local fiscal policies (e.g., expenditures on health and education) either have been totally unexplored or taken simply as exogenous in regional economics.

Studies in local government finance can be broadly categorized as to revenue and expenditure analysis. Traditionally, local government revenues and expenditures have been treated as the two faces of one coin with revenue studies emphasizing tax incidence, while expenditure studies emphasize benefit. In explaining variations in either the level of expenditure or that of revenues, most local public finance studies have used essentially the same set of explanatory variables such as income, employment, population density, etc. However, these variables are treated as exogenously determined without exploring the possibility that local taxation and expenditures may have feedback effects on employment growth and migration. Because of the growing importance of the local government sector, theories of regional growth must be synthesized and integrated with those of local public finance.

Although various interdependent aspects of regional growth due largely to labor supply increases and local government finance have been gradually explored by Greenwood (see references 7 and 8), Henderson (see reference 9), Hirsch (see reference 10), Horowitz (see reference 11), Leven et al. (see reference 14), among others after Tiebout (see reference 27), an integrated framework for empirical analyses has only been presented recently by Liu (see references 16 and 18). In his model, Liu treated both sectors of local government finance and regional employment growth as simultaneously determined in such a way that any exogenous change in one would affect another. Empirical results and significant correlations were derived for revenues and expenditures at the aggregate levels from the large metropolitan areas in the United States. Finally, Liu concluded that interregional migration decisions observed for private citizens and public decisions on fiscal policies are mutually influential, and that household heads are attempting to maximize their quality of life by operating their maximal consumption of public to private goods and services to their respective cost ratios.

In general, the primary concern of this paper is with the differential rates of growth brought about by net migration and the disaggregate local government functions and particularly with their provision of health and educational services. In the following sections, a hypothetical model consisting of both the public and private divisions will be delineated first, followed by a presentation of the empirical results. The last section contains some policy indications and concluding remarks.

A TENTATIVE MODEL OF SYNTHESIS

Like a nation, every standard metropolitan statistical area (SMSA) performs a variety of economic functions, ranging from production and distribution to consumption. However, socioeconomic indicators such as the level and growth rate of per capita income, total employment, population structure, etc., differ considerably among SMSA's within this nation. To explain differential rates of regional growth, Borts and Stein (see reference 2) have suggested that, under a framework for general equilibrium analysis, the demand for a region's exports and its supply of capital are perfectly elastic. These, together with fixed land and probably limited entrepreneurship, imply that regional economic growth depends substantially on labor supply, the remaining factor of production. Further, they also hypothesize the presence of constant returns to scale. Thus, labor force and employment would increase in proportion to any population increase. While population increase in any region is brought about through natural increase and inmigration, few variations in birth and death rates have been observed among all the large SMSA's in the United States; and thus, the most important factor that results in differential growth in population and employment is migration.

In a regional growth model recently developed by Muth (see references 20 and 21), migration and employment growth are hypothesized as simultaneously determined. One affects and is affected by the other. Based on the proposition advanced by Borts, Stein, and Muth, we have chosen the differential rates of net migration and employment growth among SMSA's as basic aspects of concern for this study. However, we have expanded on the contributions made by the above authors by considering the interaction between employment growth, net migration, and local government finance.

In addition, unlike previous studies of local government finance in which revenues and expenditures are treated either as an identity or as the two faces of one coin, taxation and expenditures are assumed to play distinctive roles in the

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process of economic changes. Furthermore, the heterogeneity of local government functions is recognized and explicit account is made for this heterogeneity. Specifically, local government functions related to health and education which possess the characteristics of investment goods and services delivered directly to human beings are differentiated from such functions as fire and police protection, street maintenance, refuse collection, etc., which possess the characteristics of consumption goods and services delivered generally to the property or land, admittedly with the purpose of serving people (see reference 10 and page 303 in this publication). Local government expenditures are thus differentiated between those for health and education and those for other public services.

In short, the five endogenous variables of the model are: Employment growth (E), net migration (M), local tax rate change (T), growth in per capita expenditures on health and education (H), and growth in per capita expenditures on other public services (G). The hypothesized relationships concerning the interaction between the set of endogenous variables are summarized below:

First, employment growth is a positive function of net migration and of growth in per capita expenditures on other public services which are supplementary inputs to other factors in private production, and a negative function of change in average tax rate. The interaction between employment growth and net migration was studied by Muth. The relationship of employment growth to change in average tax rate has been analyzed rather thoroughly in location theory and other literature related to economic growth,[1] without clear empirical acceptance or rejection. However, the hypothesis concerning the effect of local government expenditure on regional economic growth has not been extensively tested, and very little is known about the effect by expenditure patterns.[2] Furthermore, even with public finance studies, much less emphasis has been placed on expenditures than on taxation.[3]

Second, net migration is hypothesized to be a positive function of employment growth and of growth in per capita local expenditures on health and education—investment in human beings—and a negative function of changes in average tax rate. A large increase in per capita local government expenditures on health and education and small increase in average tax rate imply relatively low private cost of public investment and services. This, together with growth in employment opportunities will encourage net inmigration—an extended Tiebout (see reference 27) hypothesis.

Third, changes in average local tax rates are a reflection of a greater need for an enlarged fiscal capacity and of taste and habit of a local community to expend on public goods and services. Logically, they are hypothesized to be a positive function of growth in both per capita expenditures on health and education and on other public services.

Fourth, growth in per capita expenditures on health and education is assumed to be a positive function of net migration and average tax rate change, and a negative function of growth in per capita expenditures on other public services. It is argued that net migration indicates additional needs (see reference 4), changes in average tax rate indicate growth in fiscal capacity of a community and its preference to expend on this category of public services, and the two types of expenditures may be substitutes.

Finally, growth in per capita expenditure on other public services is hypothesized to be a positive function of change in average local tax rate, a negative function of employment growth, and of change in per capita local expenditures on health and education. The effects of tax rate change on expenditures for other public services are obviously related to the willingness of a community to expend on public services. The negative relationship of employment growth to growth in other public services is possibly due to the prevalence of economics of scale in the provision of this category of other public services (see reference 10 and page 332 in this publication).

The rationale underlying the hypothesis that the growth in health and education expenditures has a negative effect on that of other public services, while the growth of the latter has a positive effect on the former is that, under a budget constraint, each local government must allocate incremental resources between competing ends. However, the nature and priorities for increased supplies of various public services are quite different. In general, health and education are considered investment goods and services, while other public services such as fire, water, and sewage serve a residual function. As a rule, this implies that health and education services are in a stronger position to claim the incremental resources of a community. In the presence of a budget constraint, a large increase in expenditures on health and education will mean that relatively small incremental resources will be available for "other" public services, i.e., both types of expenditures are substitutes. However, if a community is in a position to expend incremental resources on other public services under a budget constraint, it must generally be able to provide larger incremental resources for health and education. In this case, both expenditures are complements.

The hypotheses described previously indicate that a simultaneously determined five-structure equation model would be an appropriate econometric framework by which metropolitan growth and local government financing can be synthesized as follows.

Net Migration Rate (M)

To provide an explanation of the differences in net migration between SMSA's, we assume that all household heads have an objective utility function. The rational household

[1] For this type of argument, see general comment of Isard *et al.* (see reference 13) and Thompson (see reference 26), Ghali and Bertrand (see reference 6), and Leven et al. (see reference 14).

[2] For a summary of the empirical results which rejected the hypothesis, see Due (reference 5). For negative results of taxes, see Struyk (reference 24) and Liu (reference 15) for positive expenditure effects.

[3] For a similar type of argument, see Thompson (reference 26), Bradford and Kelegian (reference 3), Singer (reference 23), and Sunley (reference 25).

heads always attempt to maximize their utility with respect to all the variables which affect their well-being or quality of life. These factors include opportunities for income and employment and the environment for investment and consumption.[4] To capture the influence of these factors, the net migration equation is specified as—

$$M = f[E, H, T, W_o, W, C, U, H_o] \quad (1)$$

and

$$\frac{\partial M}{\partial E} > 0, \frac{\partial M}{\partial H} > 0, \frac{\partial M}{\partial T} < 0, \frac{\partial M}{\partial W_o} > 0, \frac{\partial M}{\partial W} > 0, \frac{\partial M}{\partial C} < 0, \frac{\partial M}{\partial U} < 0, \frac{\partial M}{\partial H_o} > 0$$

The importance of employment growth (E) as a determining factor in migration can be seen in the suggestion by the Advisory Commission on Intergovernmental Relations that "The lure of improved economic opportunities is a major factor promoting migration . . . Areas of high economic activity, for obvious reasons are major focal points at inmigration" (see reference 1 and page 45 in this publication). In an area where there is a high rate of employment growth, not only does the availability of employment opportunities attract inmigration, but workers may also be recruited and transferred from other geographical areas by business firms. By the same token, the growth in unemployment rate (U) can be expected to have a negative effect on inmigration.

Economists have emphasized the importance of the level of and changes in wage rates as determinants of an individual's decision regarding employment and migration. In general, rational behavior will lead some individuals to migrate in response to differentials and changes in manufacturing wage rates (W_o[5] and W,[6] respectively). It is recognized that only real income matters. Thus, costs of living are also a relevant variable in an individual's decision to migrate. However, statistical data concerning the differential costs of private goods and services are not available for all the SMSA's included in this study. Therefore, this variable is not employed in this study. However, we have substituted the price of obtaining public goods and services as indicated by average local tax rates. As noted earlier, rational individuals will react negatively to high costs of public goods and services and are very sensitive to the changes in local tax rates (T).[7]

In contrast to the negative response to high tax rates, the migrant's response to expenditures on health and education (H_o)[8] is likely to be positive. These expenditures, which represent the benefit side of local government finance, are likely to be particularly important to migrants, most of whom are relatively young with children to educate. A large increase in per capita expenditures on health and education (H) improves both the quantity and quality of these public services, which in turn provides an improved, and an expected improvement in, investment opportunity for the education of younger generations.

Changes in crime rates (C) are included in the migration equation as a proxy for the quality of the investment and consumption environments. Increases in crime rates indicate deterioration in the environment and prospective migrants are likely to be discouraged from such areas.

Employment Growth (E)

In the specification of employment growth equation, it is assumed that there are factors which either generate, facilitate, or induce economic changes. Such variables include: Growth in per capita expenditures on other public services such as fire, police, water system, street repairs, etc. (G); changes in average local tax rate (T); crime rate (C_o);[9] average tax rate (T_o);[10] the level of per capita expenditures on other services at the beginning of the study period (G_o);[11] natural increase in population (P); and change in crime rate (C). The employment growth equation is—

$$E = f(M, G, T, C_o, T_o, G_o, P, C)$$

and (2)

$$\frac{\partial E}{\partial M} > 0, \frac{\partial E}{\partial G} > 0, \frac{\partial E}{\partial T} < 0, \frac{\partial E}{\partial C_o} < 0, \frac{\partial E}{\partial G_o} < 0, \frac{\partial E}{\partial T_o} > 0, \frac{\partial E}{\partial P} > 0, \frac{\partial E}{\partial C} < 0$$

Net migration (M) is included as an explanatory variable for the reason that it is a major source of labor supply, which facilitates economic change. Crime rate and its change are included in this equation as an indicator of community environment. A low rate of crime or a small increase in the crime rate is conducive to employment growth and vice versa. Population increase represents a shift in the supply of labor and demand for products. An increase in population will therefore generate economic change.

Per capita expenditures on other services and changes in these expenditures, average local tax rate at the beginning of the study period, and changes in this tax rate are included in this equation to account for factors which facilitate employment growth. Specifically, expenditures on other public services represent efforts to provide better industrial climate and business environment in the community.[12] This implies that, other things being equal, the higher the level and the

[4] The hypothesis that rational individuals attempt to maximize their quality of life rather than capitalize their income or employment opportunity has been studied and accepted by Liu (see reference 17), Greenwood (see reference 7), and others.

[5] Manufacturing wage rate in 1960.

[6] Change in manufacturing wage rate. Defined as the ratio of 1970 and 1960 data. Where 1960 data are not available, the average of 1957 and 1962 data was used.

[7] As R. Struyk has pointed out, low tax rates and their minimal changes are also decisive inducements to attract and hold business and industry (see reference 24).

[8] Per capita local government expenditures on health and education in 1960.

[9] Number of crimes per capita in 1960.

[10] Average local tax rate in 1960.

[11] Per capita local government expenditures for other services in 1960.

[12] As Advisory Commission on Intergovernmental Relations has stated—"Government Policy can affect factors such as the need for adequate transportation, . . . industrial climate . . . all of which are influential in the location decision" (see reference 1).

greater the increase in these expenditures, the greater the rate of economic development and employment growth. In contrast to expenditures, taxes are costs to both consumers and producers alike. Areas which have low initial tax rates or have experienced small increases in tax rates are likely to be more attractive to both consumers and business firms than areas where taxes are high and are increasing rapidly. The level and changes in average tax rates not only affect the extent of migration but also business decisions concerning expansion and relocation of plants.

Average Local Tax Rate Change (T)

The differential changes in average tax rates which exist between SMSA's are undoubtedly a result of interaction between willingness to raise taxes and changes in the need and capacity to increase expenditures. It is generally believed that the "need" factor provides a basis for the minimum level of taxes. As compared with need, fiscal capacity imposes an upper ceiling on the rate of taxation.[13] Changes in the capacity for tax efforts will therefore lead to changes in the upper ceiling.

It is suggested in this study that the actual tax rate lies somewhere between the minimum level required by needs and the capacity for tax efforts. Within the limits imposed by need and capacity, the willingness of the community to contribute will determine the point around which the actual rate will be set.

To account for the influence of the need, fiscal capacity, and willingness of a community to raise taxes, the change in tax rates equation is specified as—

$$T = f[M, H, G, C_o, T_o, Y, S, C, K]$$

and (3)

$$\frac{\partial T}{\partial M} > 0, \frac{\partial T}{\partial H} > 0, \frac{\partial T}{\partial G} > 0, \frac{\partial T}{\partial C_o} < 0, \frac{\partial T}{\partial T_o} > 0, \frac{\partial T}{\partial Y} < 0, \frac{\partial T}{\partial S} < 0, \frac{\partial T}{\partial C} < 0, \frac{\partial T}{\partial K} > 0$$

Net migration (M), changes in per capita expenditures on health and education (H), and those on other public services (G) are incorporated in the average tax rate change equation to account for the magnitude of the need or change in the need for tax rate increase. Inmigration increases the population of a community, which creates greater need for public services, for which additional revenues must be obtained.[14] Similarly, increased expenditures on health, education, and other public services imply that additional resources must be acquired. Such resources, for the most part, can be obtained only through tax rate increases.

Crime rate at the beginning of the study period, change in the crime rate, and change in per capita income are included in the average tax rate equation for the reason that these variables reflect the environmental factors underlying the capacity for tax efforts. It is argued that high crime rates and large increases in crime rate have adverse effects on economic activity, which will have negative effects on the fiscal capacity of a community with respect to its tax efforts.

As a general rule, we can expect the fiscal capacity for tax efforts to increase with income. But one might also argue that tax rates do not increase in direct proportion to income. If this is the case, the average tax rate (T), which is expressed as the ratio of tax revenue to income, may be expected to decrease with income.

To account for the effect of willingness or tastes and habits of a community to contribute to a tax rate increase, average tax rate at the out-set of the study period (T_o) and changes in average state tax rate (S) are included as explanatory variables. The rationale is that, other things being equal, the higher the initial tax rate or the larger the increase in average State tax rate, the greater willingness a community has to contribute to tax efforts. In addition to the variables described above, changes in teacher-student ratios (K) are included as a proxy for changes in the quality of public services.[15] It is hoped that the greater the ratio, the higher the quality of public services in general, and education in particular. But other things being equal, higher quality can be obtained only through additional resources, which in most cases must be financed through taxation.

Changes in Per Capita Expenditures on Health and Education (H)

As previously pointed out, expenditures on health and education can be more properly considered as social overhead investment than public consumption.[16] The differences in the proportionate changes in this category of expenditures between SMSA's therefore can be attributed to differences in the willingness to invest and to differential changes in the need and ability to invest in this category of public goods and services. In addition, qualitative changes may also account for a part of the variation.[17] These suggest that—

$$H = f[M, G, T, D_o, H_o, K, P, R_o, R]$$

and (4)

$$\frac{\partial H}{\partial M} > 0, \frac{\partial H}{\partial G} > 0, \frac{\partial H}{\partial T} > 0, \frac{\partial H}{\partial D_o} > 0, \frac{\partial H}{\partial H_o} < 0, \frac{\partial H}{\partial K} > 0, \frac{\partial H}{\partial P} < 0, \frac{\partial H}{\partial R_o} > 0, \frac{\partial H}{\partial R} > 0$$

[13] This is based on the assumption that fiscal capacity exceeds the minimum efforts that are needed.

[14] For a study of the effect of migration on local tax burden, see Crowley (reference 4).

[15] Changes in teacher-student ratio may also indicate the preference of the community with respect to public investment goods.

[16] It is recognized that the demand for and supply of public goods differ from that for private goods. This is so because public goods must be provided collectively, and no exclusion principle can be applied and no charge can be assessed at the point of consumption. In addition, there are added problems of externalities.

[17] Several authors including Ridley and Simon (see reference 22) and Isard and Laughlin (see reference 12), have attempted to measure both quality and quantity of output of local government. In addition, Henderson has used a community welfare function to derive a simultaneous equation model for local government expenditures (see reference 9).

In the specification of a net migration equation, expenditures on health and education were assumed to create conditions which are conducive to inmigration. However, a large proportion of the population who migrate are relatively young and have children to educate. This implies that inmigration (M) will create added need and necessitate increased spending on health and education. As explained previously, changes in per capita expenditures on other services (G) is included to test the hypothesis that the variation in this category of expenditures is associated with that for health and education.

The ability of a local government to finance the provision of public services depends on both internal resources and external grants. Internal resources consist mostly of revenues derived from taxation. Average tax rate change (T) is therefore included as an explanatory variable for the reason that it indicates the fiscal capacity and willingness of a community to expend on health and education, as suggested by Henderson (see reference 9), Maxwell (see reference 19), and others. External resources of a local government are derived from Federal and State grants, which for the most part are to be used to finance health and education programs. By enhancing the fiscal capacity of local government, Federal and State grants and their changes (R_o[18] and R[19]) are expected to have a positive effect on per capita expenditures on health and education.

Population density (D_o)[20] is included in the health and education expenditures equation for the reason that it is a representative characteristic indicative of the relative cost of providing health and education services.[21] In contrast, the natural population growth (P) is included to examine the economies of scale. In general, we expect relative costliness to increase with population density. Changes in teacher-student (K) ratios are included as a proxy for qualitative changes in the provision of health and education on the assumption that the quality of education varies positively with teacher-student ratios.

In this study, we have also hypothesized that per capita health and education expenditures move toward an equilibrium. To test this hypothesis and to provide a measure of the impact of the initial expenditure level on subsequent changes, the initial level of per capita expenditures (H_o) is included as an explanatory variable of negative effect, meaning that high initial expenditure will necessitate only a small subsequent increase and vice versa.

Changes in Per Capita Expenditures on Other Public Services (G)

In contrast to health and education which represent social overhead investment, the other public services considered here include fire and police protection, refuse collection, and street repairs. These other services are for the most part for remedial purposes. Nevertheless, it can still be argued that expenditures on this category of services depend on such basic factors as need, fiscal capacity, and taste and preferences of the community.[22]

To account for the influence of these factors we postulate:

$$G = f[E, H, T, C_o, X_o, C, U, G_o]$$

and (5)

$$\frac{\partial G}{\partial E} < 0, \frac{\partial G}{\partial H} < 0, \frac{\partial G}{\partial T} > 0, \frac{\partial G}{\partial C_o} > 0, \frac{\partial G}{\partial X_o} < 0, \frac{\partial G}{\partial C} > 0, \frac{\partial G}{\partial U} > 0, \frac{\partial G}{\partial G_o} < 0$$

In equation (5), the hypothesis that increased expenditures on health and education (H) are at the expense of those for other public services can be tested. Employment growth (E) is used as proxy for a change in the aggregate fiscal capacity of a community. Our hypothesis is that per capita expenditures on other public services as a residual function do not necessarily change in direct proportion to the growth in the aggregate fiscal capacity of a community. In addition, there may be economies of scale in the provision of those other goods and services.

Changes in average tax rates (T) are incorporated on the assumption that it indicates the willingness of a community to provide public goods and services. Since the other services are financed primarily from local sources, expansion in these services can be accomplished only through community willingness, represented by the local tax efforts. Crime rate and its change (C_o and C[23]) and changes in unemployment rate (U) are included as indicators of the need and changes in the need of a community for the other category of public services, particularly fire and police protection. The proportion of families with incomes under $3,000 ($X_o$)[24] indicates the extent of poverty. This variable indicates the fiscal inability of a community to provide incremental resources for additional public services.

Per capita expenditures on other public services at the beginning of the study period (G_o) are included in the equation to test the hypothesis that there is an equilibrium to

[18] Per capita Federal and State grants to local governments in 1960.

[19] Change in per capita Federal and State grants to local government. Defined as the ratio of 1970 to 1960 data. Where 1960 data are not available, the average of 1957 and 1962 data was used.

[20] Population density per square mile in 1960.

[21] Population density is highly correlated with the size of SMSA's. Thus, the former can be regarded as an instrumental variable for the latter. However, as Isard and Laughlin have observed, there are some diseconomies of scale in the production of public goods and services.

[22] Given the nature of the services involved, one can easily argue that the relative importance of the three factors—need, capacity, taste, and preferences—in the determination of expenditures on these services differ from those for health and education. In other words, being remedial in nature, expenditures on other public services may be predominantly influenced by the need factor which is defined as a minimum acceptable standard given the tastes and desires of a community.

[23] Change in crime rate. Defined as the ratio of 1970 to 1960 data where 1960 data are not available, the average of 1957 and 1962 data was used.

[24] Percent of families in 1960 with 1959 income under $3,000.

which per capita expenditures on these services is adjusted. It implies that a large initial expenditure will mean a small subsequent increase in this expenditure.

ANALYSIS OF STATISTICAL RESULTS

The data used in this study consist of observations of 51 of the largest standard metropolitan statistical areas (SMSA's) covering the decade 1960 to 1970. Even though the actual number of SMSA's with 1960 population, greater than 500,000 people, exceeds the number included in this study, some are excluded either because their geographical boundary is not entirely within a State or complete statistical data are not available for all the variables which appear in the model.[25] The structural equations of the model described in the previous section were estimated with both two-stage and three-stage methods. The results obtained by the two-stage and three-stage methods were essentially similar, which implies that there are no series problems of intercorrelation between the disturbance terms of the structural equations. Because of this similarity, we present only the results of the three-stage least squares estimation for each of the equations in table 1.

An examination of the estimates shown in table 1 indicates that most hypotheses described previously are supported by the data. Of the 15 hypothesized relationships among the endogenous variables, 11 are estimated with consistent and statistically quasi-significant results.[26]

Briefly, employment growth has a significant influence on net migration, which in turn, has a significant effect on employment growth. Net migration affects and is affected by growth in per capita local expenditures on health and education. Changes in both categories of expenditures (health and education and other public services) have positive effects on changes in tax rates. Changes in average local tax rates have significant positive effects on per capita expenditures for health and education. Changes in average tax rates have negative effects on employment growth, which has a significant negative effect on growth in per capita expenditures on other services. Finally, growth in per capita expenditures on health and education has a negative effect on that for other public services, while the effect of the latter on the former is positive. The four hypothesized relationships between the endogenous variables not supported by our estimates are: (1) The mutual influence between net migration and changes in average local tax rate, (2) the effect of changes in average local tax rates on growth in per capita expenditures on other public services, and (3) the positive effect of changes in per capita expenditures on other services on employment growth.

The effects of predetermined variables on each of the left hand side endogenous variables are described below.

First, the estimates in equation (1a) indicate that the coefficients for initial and change in wage rates (W_o and $\dot{W}$) are not statistically significant, but the change in unemployment has a significant effect on net migration. These results indicate that employment opportunities rather than tax rate or wage rate have effects on migration. The result also supports the hypotheses that increased crime (C) discourages inmigration and that migrants do respond to initially high per capita expenditures on health and education (H_o).

Second, equation (2a) indicates that in addition to inmigration, the natural increase in population (P) has a significant effect on employment growth. The results also show that in addition to local tax rate change (T), initial high tax rate (T_o) had an adverse effect on employment growth. The hypotheses that crime rate and its increase have a negative effect on employment growth are not supported by the results. The coefficient for lagged other expenditures does not have a correct sign and is not statistically significant. Thus, expenditures on this category of public services do not have a significant effect on employment growth.

Third, the hypotheses that crime rate and its change have a negative effect on changes in tax rates are supported by the estimates. The results also indicate high initial tax rate (T_o) and a large increase in State average tax rates (S) are associated with a large increase in local tax rate; changes in teacher-student ratio (K) have a positive effect on tax rate. On the other hand, average local tax rate did not increase in direct proportion to change in income (Y).

Fourth, the hypothesis that growth in per capita expenditures on health and education is positively related to change in teacher-student ratio and to the natural population increase is not consistent with the results. However, the growth in this expenditure is significantly influenced by population density (D_o) and the level and change in Federal and State grants (R_o and R). The estimated statistics for initial per capita expenditure on health and education confirm the proposition that a high level of initial per capita expenditures on the average is associated with a small subsequent increase in expenditures. This is consistent with the hypotheses that there is an equilibrium to which per capita expenditure on health and education is adjusted.

Finally, growth in per capita expenditures on other public services is significantly influenced by crime rate and its change, and the extent of poverty (X_o). The effect of unemployment rate is positive but significant at only the 10 percent level. The coefficient for initial expenditures on this category of services is negative. Again, this is consistent with the argument that there is an equilibrium to which expenditures on this category of services are adjusted.

IMPLICATIONS AND CONCLUDING REMARKS

This study provides a theoretical framework linking metropolitan growth with local government finances. The endogenous variables considered are net migration, employment growth, average tax rate change, expenditures on health and education, and that on other public services. The rationale for

[25] The list of SMSA's and data sources can be obtained from the authors upon request.

[26] A coefficient is said to be quasi-significant if its value is approximately twice as large as its estimated standard error.

Table 1. Statistical Estimates of the Model

Equation:											
(1a)	M =	.7198	+.1893E	+.0851H	-.0259T	-.0107W	+.0644W	-.0724C	-.0552U	+.7908H	
		(.2131)	(.0755)	(.0278)	(.0249)	(.0108)^{o}	(.1168)	(.0212)	(.0314)	(.1734)^{o}	
(2a)	E =	.2100	+1.1700M	-.0124G	-.0342T	-.0002C	-.0279T	-.0248G	+.9848P	+.0030C	
		(.0764)	(.0709)	(.0120)	(.0191)	(.0002)^{o}	(.0122)^{o}	(.0349)^{o}	(.0349)	(.0163)	
(3a)	T =	.4740	-.2849M	+.1331H	+.1561G	-.0025C	+.6863T	-.1852Y	+.9560S	-.1743C	+4.6170K
		(.5575)	(.6770)	(.0723)	(.0807)	(.0014)^{o}	(.3628)^{o}	(.0639)	(.2141)	(.1011)	(1.7995)
(4a)	H =	5.8520	+5.3862M	+.4644G	+.3467T	+.0052D	-11.2847H	-1.6214K	-.1178P	+5.0815R	+.0930R
		(1.0722)	(1.6475)	(.1807)	(.1970)	(.0030)^{o}	(2.0817)^{o}	(2.7044)	(.6326)	(1.6623)^{o}	(.0551)
(5a)	G =	5.1224	-.8722E	-.2717H	+.2729T	+.0074C	-.0547X	+.7492C	+.2927U	-2.0783G	
			(.4546)	(.1268)	(.1829)	(.0023)^{o}	(.0156)^{o}	(.1960)	(.2285)	(.4239)^{o}	

Note: The estimated standard errors are in the parentheses; coefficients of wrong signs are underlined.

Endogenous Variables

M Net migration rate: Defined as the ratio of net migration between 1960 and 1970 to 1960 population.
E Employment change.*
H Change in per capita local government expenditures on health and education.*
G Change in per capita local government expenditures on other public services.*
T Change in average local tax rate.*

Exogenous Variables

C Change in crime rate.*
C_o Number of crimes per capita in 1960.
D_o Population density per square mile in 1960.
G_o Per capita local government expenditures for other services in 1960.
H_o Per capita local government expenditures on health and education in 1960.
K_o Change in teacher-student ratio.*
P Natural increase in population.*
R Change in per capita Federal and State grants to local government.*
R_o Per capita Federal and State grants to local governments in 1960.
S_o Change in average State tax rate.
T_o Average local tax rate in 1960.
U_o Change in unemployment.*
W Change in manufacturing wage rate.*
W_o Manufacturing wage rate in 1960.
X_o Percent of families in 1960 with 1959 income under $3,000.
Y_o Change in per capita income.*

*Defined as the ratio of 1970 to 1960 data. Where 1960 data are not available, the average of 1957 and 1962 data was used.

classifying local expenditures in two categories was that the former represents social overhead investment while the latter can be more appropriately considered as public consumption.

Despite the absence of definite statistical evidence concerning 4 of the 15 hypothesized relationships, our statistical results for the most part support the proposition that there are important interactions between migration and employment growth, as argued by Muth (see references 20 and 21) and Greenwood (see references 7 and 8), and between local government finances, as described by Henderson (see reference 9) and Horowitz (see reference 11). Furthermore, the hypothesis that metropolitan growth and local government finances are mutually influential as developed by Liu (see references 16 and 18) has been once again supported with differentiated expenditure patterns described earlier by Tiebout (see reference 27).

From the viewpoint of public policy, several aspects of this study are rather interesting.

First, changes in expenditures on health and education induce inmigration, which in turn has a positive effect on employment growth. For an SMSA aspiring to promote economic change, it is essential to provide health and educational services. However, average local tax rate changes have negative effects on employment growth. This implies that for an SMSA which aspires for growth, the strategic approach is to increase or improve health and educational services but seek to finance such increase or expansion through external sources such as Federal and State grants or funds generated through revenue sharing. Otherwise, the negative effect of the local tax rate change may offset the positive effect of expenditures on economic growth. In this regard, the funds that have been allocated to local governments through Federal revenue sharing possess the desirable characteristics and have significant implications. However, since each local government has been, and will continue to, allocate its receipts from revenue sharing with discretion, the effect on economic growth of this new federal fiscal action can also be expected to differ between SMSA's.

Second, the mutually reinforcing relationships between employment growth and migration, migration and changes in expenditures on health and education, and the expenditure and tax rate changes are found to be very significant. It is also very interesting to note the one way, negative influence of the tax rate on employment growth, which magnifies the public development strategy by offering tax advantages or better environment to private investors at the expense of an increasingly alarming indebtedness problem at the city hall. As it now stands, a city's earnings tax may warrant special consideration.

Third, the significant relationship between the two types of expenditures and the tax rate variable illustrates the fundamental distinctions among the underlying budgeting decisions of a local government, i.e., the remedial nature of other expenditures for a given budget and the vital emphasis on human investment over the consumption expenditures in the past years.

Fourth, the findings of this study concerning the negative relationships of employment growth to changes in per capita expenditures for other public services also has important policy implications. Specifically, this negative relationship implies that, on the one hand, there may be some economies of scale in the provision of public consumption goods and services as employment growth occurs; and on the other hand, any plans contemplated to cut down consumption of public goods and services probably should be replaced by a decision to seek maximum employment growth.

Finally, this study indicates that tax rate changes are heavily dependent on a community's willingness (or tastes and habits) concerning tax efforts. In contrast, there appears to be some equilibrium to which per capita expenditures are adjusted. The multitude of institutional and economic forces suggest it is unlikely that per capita expenditures in any community will grow greatly out of line in comparison to other communities. There also appears to be a ceiling for tax rate change determined exogenously by the model and acting as price adjusters between the investment and consumption decisions made over both the public and the private markets.

Although the findings in this paper are tentative, the implications on revenue sharing funds and tax rates on the relationships between investment and consumption appropriations and the interdependence between migration and employment growth have successfully opened up a new avenue for further integration of regional growth and local finance analyses.

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Toward the Measurement of the Housing Services Component for the Demand for Local Public Services

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INTRODUCTION

The Federal government has increased its funding of programs that promote private structural housing improvements. The Community Development Act of 1974, for example, provides block grants to local governments for the upgrading and preservation of the housing stock. The use of Community Development funds for new construction is not allowed.[1] This type of program has raised a couple of old questions: What types of improvements should the government fund? Would the funds be better spent on other components of the housing services bundle? To resolve questions of this nature, researchers have utilized housing market "hedonic" analysis.[2] With z_i, $i = 1, \ldots, n$, representing the i^{th} characteristic of a house, and $P(z)$, expressing the price of the vector, z, of characteristics (the price of the house), researchers first regress $P(z)$ on the set of z_i:

$$P(z) = a + b_1 z_1 + ... + b_n z_n + e \quad .$$

The regression parameter estimates, $dP(z)/dz_i = b_i$, are then discussed as if they were marginal prices.[3] If houses are exchanged in equilibrium, what sense can we make of such a regression? Is it a supply function, a demand function, or both? In this paper we shall see that this function may be either one. The answer depends on whether or not one side of the market is exogenous to the system. Usually, both sides of the market are endogenous. The utilization of an assumption that one side of the market is exogenous may reflect data inadequacies or the lack of a technique to estimate a housing model which presupposes an endogenous supply and demand for housing. The purpose of this paper is to specify the analytics and econometric estimation technique that will generate housing characteristics supply and demand functions in competitive markets.

In the first section, Rosen's analytical model of characteristics markets is applied to a competitive housing market. Next, we shall examine the econometric estimation problem and develop a method to estimate the housing characteristics supply and demand curves. Finally, in the third section, an application of the technique is made using data collected by the Durham, N.C., Urban Observatory.[4]

THE HOUSING CHARACTERISTICS MARKET

In a pathbreaking analytical study, Sherwin Rosen (see reference 10) developed a model of a generalized competitive characteristics market, and demonstrated the simultaneous equation problem in characteristics space. If the supply and demand for characteristics are endogenous, the hedonic price function is an analog of a line connecting the intersections of shifting supply and demand curves. Thus, one may not actually obtain a measure of the demander's preference function, but instead one may be acquiring information about supply behavior. Before we detail a technique for estimating characteristics supply and demand functions, we shall develop a model of a competitive housing characteristics market.

Expressing the housing services bundle in terms of measurable characteristics or attributes actually considered by market agents is the housing market, hedonics literature's point of departure from earlier analyses.[5] Attribute bundles include locational advantage, private characteristics as the number of rooms, type of heating and plumbing, etc., and governmentally provided goods and services as schools, police and fire protection, etc. Let us define this set for any house with a real vector $z = (z_1, z_2, \ldots, z_m)$, where $z_i = i^{th}$ characteristic produced by a given bundle of housing services. Additionally, we shall assume: (1) Buyers and sellers are price takers in competitive characteristics space markets, and (2) there is a sufficiently large number of differentiated houses so that choice among the z can be considered continuous.[6] Each component, z_i, shall be expressed in terms of market goods, that is, the safety rate (a good) is obtained by taking the inverse of (a bad) the crime rate.

Housing consumers are assumed to purchase only one house, which can be characterized by its z vector. We shall further assume the utility function of housing consumers are

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[1] Document supplied by the Community Development Program, Durham City Planning Division, June 1975.

[2] Bailey, Muth, and Nourse (1963) were first to extend Griliches' (1961) method of hedonic price index construction to housing. Musgrave (1969) of the Bureau of Economic Analysis continues the application and development of this price index.

[3] A. Thomas King discusses the regression coefficients as marginal prices in his new book (1973) which examines the Newhaven, Conn. housing market. James T. Little (1975) and Leven and Mark (1975) similarly discuss the method for estimating revealed preferences. The problem of separating the supply and demand sides of the market has not gone unnoticed even in the hedonic price index literature. There, the problem is discovering the relationship between sales price and construction cost indexes. Bhatia (1971) recognized "Under rather strong assumptions about the stock-flow relationship in the housing market and demand and supply of construction inputs, a good construction cost indices can reflect changes in the price of houses, but basically the two types of indices are not comparable and should not be used interchangeably," (p. 25). Generally, authors make no mention of the supply side, and assume hedonics measures revealed preferences. For example see Leven and Mark (1975).

[4] Seamus O'Neill who nobly served as research assistant for the Durham Urban Observatory deserves a special note of thanks for collecting the exogenous supply variables especially for this study, and for his assistance in the early stages of the estimation process.

[5] This application of Lancaster's "New Theory of Consumer Demand" (1966) is the foundation for the characteristics market in Rosen's extension (1974).

[6] This permits us to use calculus instead of programming techniques which would add little to our exposition.

identically and strictly concave, but differ due to a set of shift variables which include socioeconomic characteristics as race, age, family size, etc. The shift variables alter the position of the utility function without changing its basic properties. The t^{th} consumer's utility function, based on z and w, a vector of all other goods and services, conditional on S_t, the vector of shift variables, is written:

$$U_t = U(w, z/S_t) \quad . \qquad (1)$$

The t^{th} consumer attempts to maximize his utility subject to the following budget constraint:

$$Y = w + (1 + T)P(z) \quad , \qquad (2)$$

where w is employed as the numeraire, Y is money income, and T is a vector of taxes in characteristics space.

From equations (1) and (2) we can construct Alonso's (see reference 1) value price or value function,

$$\theta(z \,/\, U, Y, T, S_t) \quad , \qquad (3)$$

by maximizing $U(Y - \theta, z)$. It represents the maximum price any potential home purchaser, with a given vector of shift variables, will pay for a vector of characteristics, holding the tax rate, utility, and income constant. A family of value functions is derived by totally differentiating both equation (1), rewritten as

(1i) $U = U(Y-\theta, z)$,

to obtain

(1ii) $dU = 0 = U_w d_w + U_z d_z$,[7]

and equation (2), rewritten as

(2i) $Y = w + (1 + T)\,\theta\,(z/U,Y,T,S_t)$,

to obtain

(2ii) $dY = 0 = dw + (1 + T)\,(\theta_z d_z + \theta_u d_u + \theta_y d_y)$,

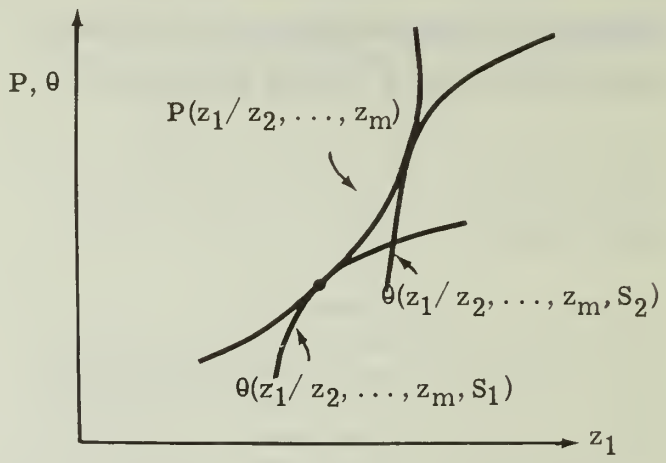
and substituting (2ii) into (1ii) to obtain

(3) $0 = 1 - (1 + T)\theta_y)dy = (1 - (1 + T)\theta_u U_w)dw$
$+ (1 + T)(\theta_z + \theta_u U_z)dz.$

Each member of the family of value functions defined by equation (3) will be concave as shown in figure 1, since the underlying utility function is concave. For any one consumer a higher value function denotes a reduced level of utility. Intuitively, paying a higher price for any given quantity of z_i results in a lowering of utility. Notice that the slope of the value function is reduced when the characteristic tax rate is raised. The consumer can maintain the same level of utility only by offering a lower price for any level of characteristic when the tax rate is increased. In figure 1, the value functions for two different housing consumers are pictured. At the set of market prices, P(z), persons with shift parameters S_2 purchase more z_1 than consumers with shift parameters S_1. The

[7] A function represented by a capital letter and subscripted denotes the derivative of the function (capital letter) with respect to the subscripted variable, e.g., $U_{z_i} = \partial U / \partial z_i$.

Figure 1

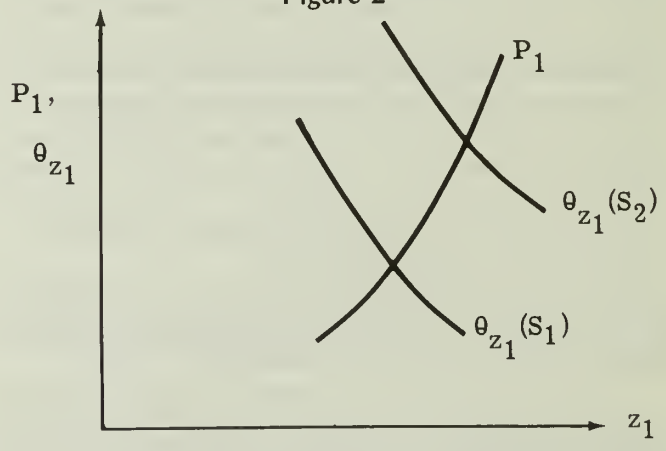


tangencies of value price functions and supplier-offered prices is represented by P(z), the "hedonic" price function.

The marginal characteristics prices a household is willing to pay is given by the slope of the value function in any characteristic dimension. From equation (3), these marginal prices are: (3i) $\theta_{z_i} = -\theta_u U_{z_i} = U_{z_i} / (1 + T) U_w$, since $\theta_u = 1/(1 + T) U_w$.

Each marginal price is essentially the marginal rate of substitution between a characteristic, z_i, and all other goods and services as corrected for the tax levied on each characteristic. Equivalently, (3i) may be considered the reservation demand price for marginal z_i. Therfore, the θ_{z_i} can be employed as demand curves for z_i. The demand curves, or sets of reservation demand prices associated with the value functions in figure 1 are plotted in figure 2.

Figure 2



Unlike renters who only consume housing services, owner-occupiers also produce or sell these services. Analytically, if the stock, instead of the flow, of housing is studied to separate the suppliers from the demanders, homeowners can simply be considered as if they sold housing (characteristics) to themselves. Prior hedonic studies of housing considered the set of bundles to be exogenously given. In characteristics space such an assumption is curious, indeed. "Home improvements" are,

in part, purchased on the basis of addition to the resale or rental value of the house. The present value calculation made by the housing supplier will include the expected market characteristic price. Suppliers determine the amount they wish to produce on the basis of P(z), the unit revenue from the vector of characteristics, z, and C(n(z), z, Y_k), the capitalized value of the cost of producing n units of a house with characteristic vector z. The vector of shift variables for seller k, Y_k, includes supplier attributes such as whether or not a management firm administers the unit, the size of the management unit, other technological variables, government subsidies and provision of inputs, etc. Let us assume the cost function is convex with positive and increasing first derivatives. The k^{th} housing characteristics seller's goal is to maximize profits, V_k, defined as –

$$V_k = n(z) \cdot P(z) - C(n(z), z, Y_k) \quad . \tag{4}$$

In the market for each characteristic, let suppliers be perfect competitors. All observe P(z), but do not recognize they have any effect on it. Maximizing profits in perfectly competitive markets, sellers will choose the optimal z when the following two conditions are satisfied:

$$\partial P(z)/\partial z_i = 1/n \cdot (\partial C(n(z), z, Y_k)/\partial z_i) \quad , \tag{5}$$

and

$$P(z) = \partial C(n(z), z, Y_k) / \partial n. \quad . \tag{6}$$

Equation (5) requires the marginal revenue from each characteric supplied to equal its marginal cost. Equation (6) adds that maximum profits result when unit revenue equals the marginal cost of producing the optimal bundle in competitive markets.

Similar to the method used to construct the consumer's value function, the seller's offer function ϕ ($z / V_k, Y_k$). It represents at constant profit per house with a given z vector, the price a seller is willing to accept when n is optimally chosen. Equations (4) and (6) rewritten below as (7) and (8) define ϕ in terms of z, V, and Y_k:

$$V_k = n(z) \cdot \phi (z / V_k, Y_k) - C(n(z), z, Y_k) \quad , \tag{7}$$

and

$$\phi (z / V_k, Y_k) = \partial C(n(z), z, Y_k) / \partial n \quad . \tag{8}$$

Based on the properties of the assumed cost function, the family of offer functions will be convex as pictured in figure 3. Producer equilibrium is characterized as the set of tangencies of profitable characteristics indifference surfaces and the market characteristics implicit price surface. The profit-maximizing levels of characteristics supplied occurs when the offer curve is tangent to the consumer's price offer. Where $P(z) = \phi(z/V_k, Y_k)$, the "hedonic" price function is once again obtained.

The marginal characteristics prices at which sellers offer their housing characteristics is given by the slope of their offer function. From equation (8), these marginal prices are:

$$\phi_{z_i} = 1/n \cdot (\partial C/\partial z_i) > 0 \quad . \tag{9}$$

Figure 3

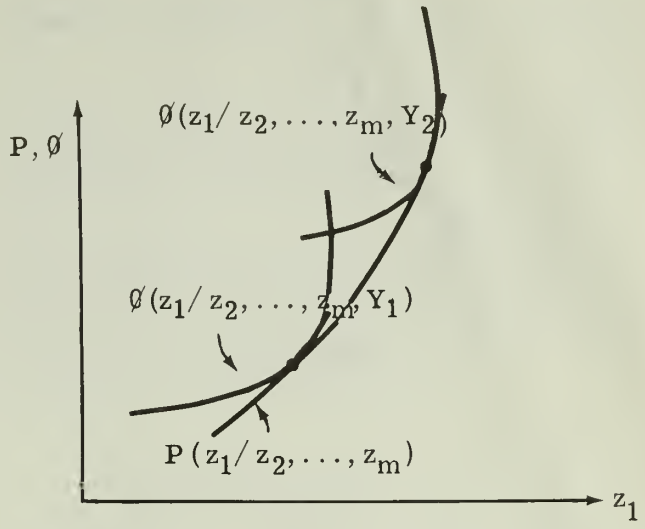
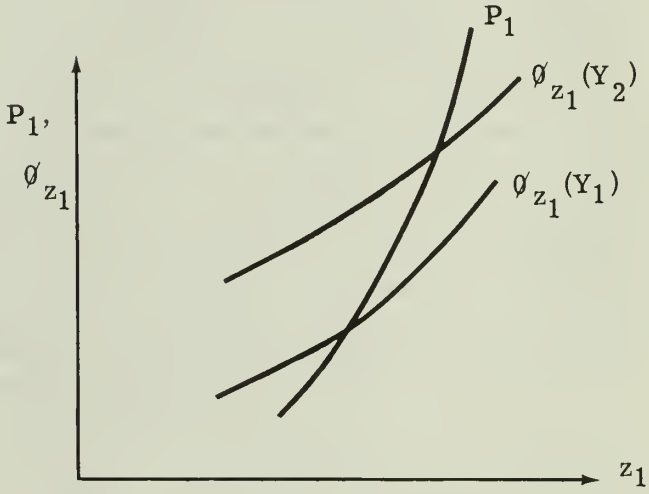


Figure 4



The slope of the offer function defines a profit compensated supply curve pictured in figure 4. We see that factors shifting the cost function, shift the offer and supply functions; hence, an input cost reduction or government input subsidy will lower the set of offer curves and raise the supply function.

Market equilibrium prices are generated by the set of tangencies of value and offer functions. Their common gradient represents the intersection of the characteristics supply and demand curves. To clarify the meaning of this construction, let us assume that the variance of Y_k equalled zero, that is, all sellers have the same offer function, in this case the offer function would be traced out by the set of consumers' value functions, as pictured in figure 5. In figure 6 the analogous situation of a characteristics supply curve being traced out by a set of its demand curves is illustrated. Alternatively, if the variance of S_t equals zero, that is, all consumers had the same value function, this curve would be traced out by the set of sellers' offer functions, shown in figure 7. Figure 8 illustrates the demand curve analog. Finally, if both the variance of S_t and Y_k were zero, there would be only one price and one standardized house observed.

Figure 5

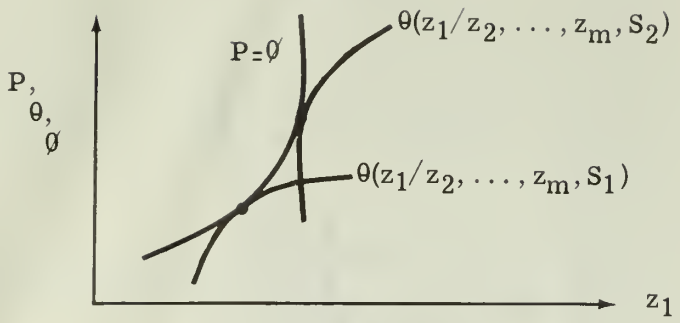


Figure 7

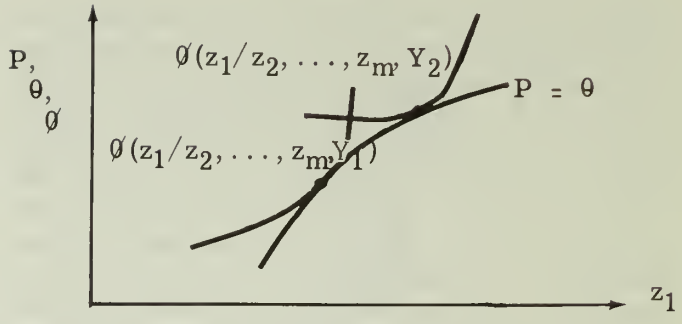


Figure 6

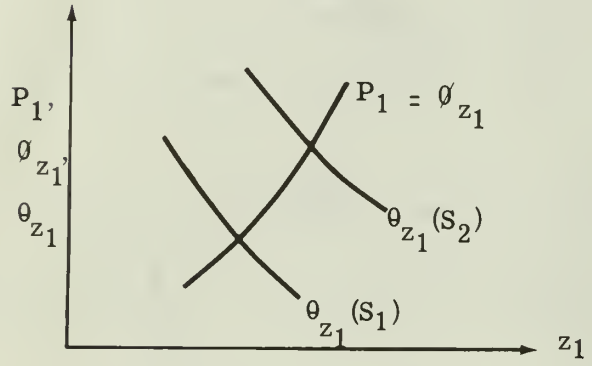


Figure 8

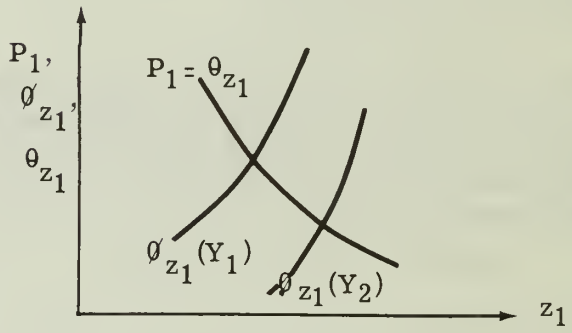
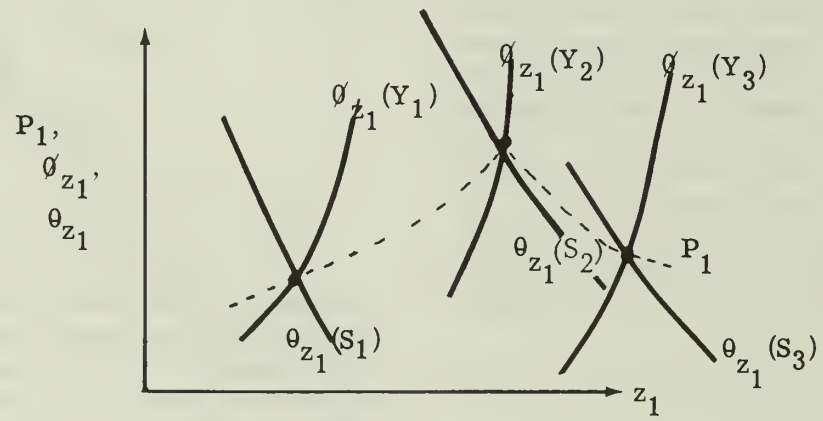


Figure 9



ESTIMATION OF THE DEMAND AND SUPPLY OF HOUSING CHARACTERISTICS

Analytically the problem of separating the demand and supply sides of the market has been resolved. However, P(z) may be a nonlinear differential equation, or in terms of the demand and supply functions derived from the value and offer functions, we may be faced with an identification problem, as pictured in figure 9. The demand curves, θ_{z_i}, the inverse of ordinary compensated demand curves for z_i, are shown for consumers with shift parameters S_t, t = 1, 2, 3. The profit compensated supply curves, ϕ_{z_i}, are shown intersecting the respective demand curves at the sales prices P_{z_i}. Equilibrium prices observed in the market place reveal little about the underlying supply and demand structures unless we are able to include sufficient exogenous variables to permit the separate identification of the two curves.

Researchers who estimated hedonic functions have been unaware of this identification problem. Rosen has characterized the general case of this identification problem in characteristics markets. To resolve the difficulty, he suggested P(z) could be estimated first, using a single equation technique. Essentially, his suggestion is to begin using the same method past researchers have employed, that is, characteristics prices could be generated as data to estimate the characteristics supply and demand curves. That procedure, however, starts with the hedonic price function (artifact); simultaneous equation bias is introduced at the initial stage of estimation.[8]

[8] I wish to thank Dudley Wallace for his assistance in recognizing this error.

The value and offer functions are not indentified in the first stage. Observed hedonic price functions are composed of intersections of characteristics supply and demand curves. The potential difficulty resulting from the failure to separate supply and demand curves is illustrated in figure 9. An inverted "v" would best fit the data, but would inappropriately represent the slopes at the value and offer curve tangencies. The use of such a function would build in the simultaneous equation bias we are attempting to surmount.

To circumvent this difficulty, the estimation procedure separates the offer and value functions in the first stage. The prices generated as derivatives (the slope at offer and value function tangencies) can then be used as data in the second stage estimation of characteristics supply and demand functions. In stage one we begin the construction of the hedonic price function by identifying value and offer curves with S_t and Y_k, their respective shift variables are—

$$P(z) = \theta\ (z / S_t) \tag{10}$$

and

$$P(z) = \phi\ (z / Y_k)\ . \tag{11}$$

Our theory suggests the value and offer functions will be concave and convex, respectively. Thus, two viable specfications of equations (10) and (11) are either a log-log or semi-log form. For exposition, we shall employ the semi-log model, and denote the log of a variable with an asterisk. In semi-log form, equations (10) and (11) become:

$$\begin{aligned}(P(z))^* = {} & a_1 + b_{11}z_1 + \ldots + b_{1m}z_m \\ & + g_{11}S_1 + \ldots + g_{1n}S_n + e_1\end{aligned} \tag{12}$$

and

$$\begin{aligned}(P(z))^* = {} & a_2 + b_{21}z_1 + \ldots + b_{2m}z_m \\ & + g_{21}Y_1 + \ldots + g_{2n}Y_n + e_2\end{aligned} \tag{13}$$

The hedonic price function is obtained by estimating the equations (12) and (13) subject to the set of restrictions: $b_j = b_{1j} = b_{2j}$; $j = 1, \ldots, n$. In this semi-log model, marginal prices may then be computed as follows:

$$\partial P(z) / \partial z_j = p_j = b_j P(z) \tag{14}$$

Marginal prices in the log-log model would equal:

$$\partial P(z) / \partial z_j = P_j = b_j P(z) / z_j \tag{15}$$

The implicit, or marginal prices paid for characteristic zj, $j = 1, \ldots, n$ can then be input as data to estimate the supply and demand curves, equations (9) and (3i), respectively. In linear form these equations are written as—

$$\begin{aligned}p_j = {} & c_1 + d_{11}z_1 + \ldots + d_{1m}z_m \\ & + h_{11}S_1 + \ldots + h_{1n}S_n + u_1\end{aligned} \tag{16}$$

and

$$\begin{aligned}P_j = {} & c_2 + d_{21}z_1 + \ldots + d_{2m}z_m \\ & + h_{21}Y_1 + \ldots + h_{2n}S_n + u_2.\end{aligned} \tag{17}$$

With m characteristics, there will be 2m equations in 2m unknowns; P_j; $j = 1, \ldots, m$, and z_j; $j = 1, \ldots, m$.

The set of supply and demand equations for characteristics are potentially the most useful tool for policy evaluation. If people vote with their feet and trades are made in a competitive equilibrium, decisionmakers who seek to maximize society's welfare will produce public characteristics up to the point that marginal benefits equal the marginal cost of providing another unit of the characteristic. This technique permits a quantitative assessment of the marginal benefits of housing service characteristics of publicly provided goods and services. Realtors and housing economists should also find this technique useful to estimate characteristic supply and demand elasticities. Next, we shall illustrate this method with a small model of the Durham, N.C., housing market.

THE DURHAM HOUSING MARKET

The following example is provided to illustrate how the procedure developed in the previous section is applied to estimate characteristics supply and demand curves. For expository purposes and due to data quality problems the model estimated here is limited to two characteristics. With more complete data available in larger housing markets, the model may be generalized in a straightforward manner to several characteristics. The essential problem in extending this technique to many characteristics is identical to another problem of previous hedonics studies. Many characteristics are sufficiently collinear to make it difficult to uniquely determine marginal prices. Two basic strategies are available to surmount this problem. One method is to use restricted least squares and include all collinear variables. An alternative is to employ factor analysis to determine marginal prices for each factor's attribute class.[9]

The housing market information used to estimate our model is drawn from the Durham, N.C. Urban Observatory data file, and census block data from the U.S. Bureau of the Census, Block Statistics, Durham, N.C. (see reference 12). The Durham Urban Observatory data set consists of 40 endogenous housing characteristics, the tax value and price at which the house was last sold, and a set of 5 exogenous supply variables. No exogenous demand variables were collected. To proxy this last set of variables, census block socioeconomic characteristics are utilized. Our premise is that even if a house purchaser does not embody a particular socioeconomic characteristic, purchasing a house in a given neighborhood reflects his own socioeconomic preferences; thus if a consumer is not a member of a given minority group, purchasing a house in a neighborhood predominantly composed of that group is assumed to indicate his utility function is similar to persons in that group. In larger metropolitan areas realtors' associations maintain more complete data files on home purchasers and characteristics. The Bureau of the Census also collects sufficient data to implement this model. Since the Durham Urban Observatory did not collect exogenous demand data, census block values will be used in this example.

[9] The use of factor analysis is discussed by John T. Scott (1966).

The small number of exogenous supply variables collected by the Durham Urban Observatory limited the number of characteristics studied to two, home heating system quality, z_1, and z_2, a measure of firesafety. Heating quality is an ordinal scale ranging from one for stoker heating to five for radiant heating. A factor analysis (with an oblique rotation of factors) showed heating quality to be associated with the same factor as other housing quality variables including interior, foundation, insulation, floor, plumbing, exterior wall quality, proportion of basement completed, and building code. The firesafety measure was computed by taking the inverse of the frequency of fire in the house's district. It is associated with the same factor as police and rescue rate, condition of streets, streetlighting, and existence of fire hydrants. Many endogenous public service characteristics contain exogenous elements. For example, the quality of housing structures and arson rate are to some extent exogenous to the behavior of the fire department. A more complete data set would be required to correct this problem.

The exogenous supply variables included in this example are S_1, a dummy variable that is zero if the unit is rented, and one if the unit is owner-occupied. The second exogenous supply variable, S_2, is a dummy variable equal to one if a management firm administers the unit, and zero otherwise. This last variable may capture the existence of economies of scale in providing housing characteristics.

The percentage of units on the census block with more than 10 units in the structure, Y_1, and the percentage of census block population that is black, Y_2, were used to proxy the exogenous demand variables. The percentage of multiunit structures is related largely to renter characteristics as the average number of renter-occupied rooms. The percentage of Black persons in the census block population is related to other race and age variables.

One major problem with the Durham data is that most of the 128 houses in the sample were not sold in 1975, the year in which the observations on many of the characteristics were collected, but were sold in the 1960's and early 1970's. Optimally, a study should use sales prices and characteristics for the same year the house was sold. This problem is not as severe in Durham as it would be in some larger cities. Many neighborhoods' characteristics have not significantly changed during the sixties and early seventies. Still, the measurement error in this data set must be recognized.

The subset of econometric routines in the University of Illinois' Statistically Oriented User's Package (SOUPAC) was used to estimate the parameters of our model. To capture the assumed properties of the value and offer functions a log-log specification was estimated as value function:

$$(P(z))^* = a_1 + b_{11}z_1^* + b_{12}z_2^* + g_{11}S_1 + g_{12}S_2 + e_1 \quad (18)$$

and offer function:

$$(P(z))^* = a_2 + b_{21}z_1^* + b_{22}z_2^* + g_{21}Y_1 + g_{22}Y_2 + e_2 \quad (19)$$

subject to the constraints: $b_{1j} = b_{2j}$; $j = 1, 2$.

Table 1 compares the unrestricted two-stage least-squares estimated (2SLS) with the restricted three-stage least-squares parameter estimates (RTSLS) of equations (18) and (19). Using the restricted estimates, we find that the exogenous variables are all drawn to statistical insignificance as their explanatory power is captured by the endogenous variables and the constant term. In the two-stage results, however, all exogenous variables are significant except the management firm variable in the offer function. Both exogenous value curve variables are found statistically significant. Notice that the restricted estimates are very close in magnitude to the unrestricted parameter estimates of both the value and offer curves. These estimates suggest that the presence of a management firm has a small positive (possibly insignificant) effect on the asking price of houses. Homeowner-occupiers also command a higher asking price than sellers of renter-occupied units. On the other side of the market, the value function of Blacks (higher percentage of Blacks in the population of the census block) is below that of non-Blacks. Lastly, persons with a preference for multiunit dwellings had relatively higher value functions than persons who preferred to live on census blocks with a smaller proportion of that type of structure.

From equation (15) and our estimates in table 1, the marginal prices of units of fire safety equal:

$$P_1 = .32138 \cdot P(z) / z_1 \quad . \quad (20)$$

Similarly, the marginal prices of units of heat quality are:

$$P_2 = 1.0356 \cdot P(z) / z_2 \quad . \quad (21)$$

Next, equations (20) and (21) were used to generate the fire and heat marginal prices for all observations. Then the resulting price data were used as observations to obtain two-stage least-squares estimates of the heat and fire safety market supply and demand curves.

The specification that was employed to estimate the supply and demand curves for characteristic i is as follows, for i,j = 1,2.

supply:

$$P_i = c_{1i} + d_{11i}z_i + d_{12i}P_j + h_{11i}S_1 + h_{12i}S_2 + u_1 \quad (22)$$

demand:

$$z_i = c_{2i} + d_{21i}P_i + d_{22i}P_j + h_{21i}Y_1 + h_{22i}Y_2 + u_2 \quad (23)$$

Our estimates for the firesafety market are shown in table 2. Similar to the results found for the offer function, in the firesafety supply curve the management firm variable is statistically insignificant. Here the basic problem of unsufficient exogenous supply variables becomes clear. Ideally, variables characterizing differences in fire technology and firesafety characteristics of the house's owner or manager would be included to identify the firesafety supply curve. The exogenous demand variables also are statistically insignificant. Whether the results of the firesafety market are due to this particular data set, or are indicative of the need for a more complete specification must await further research.

The private characteristic, heat quality, estimates shown in table 3 are much superior to those obtained for the firesafety

Table 1. **Regression Estimates of the Offer and Value Curves of the Durham Housing Characteristics Market**

Item	Dependent variable intercept		z_1	z_2	S_1	S_2
Offer curve:						
2-stage least squares	P(z)	9.520	.310	.788	.445	.058
		(17.33)	(2.72)	(3.06)	(3.03)	(.31)
Restricted 3-stage least squares	P(z)	9.657	.321	1.036	.039	.003
		(19.07)	(3.08)	(4.54)	(.62)	(.03)
			z_1	z_2	Y_1	Y_2
Value curve:						
2-stage least squares	P(z)	8.652	.208	1.094	-.004	1.560
		(14.76)	(2.10)	(4.48)	(-2.67)	(2.65)
Restricted 3-stage least squares	P(z)	9.691	.321	1.036	-.001	.166
		(19.23)	(3.08)	(4.54)	(-.57)	(.65)

Note: Ratios appear in parentheses.

Table 2. **Regression Estimates of the Firesafety Supply and Demand Curves**

Item	Dependent variable intercept		z_1	P_2	S_1	S_2
Supply	P_1	2,326.4	1,920.5	.0013	709.1	253.3
		(3.17)	(2.14)	(.14)	(1.31)	(-.36)
			P_1	P_2	Y_1	Y_2
Demand	Z_1	23.37	-.00007	-.00005	8.71	.0017
		(3.15)	(100)	(100)	(-.48)	(.02)

Note: Ratios appear in parentheses.

Table 3. **Regression Estimates of Heat Quality Supply and Demand Curves**

Item	Dependent variable intercept		P_1	z_2	S_1	S_2
Supply	P_2	1,356.47	-.0017	287.97	-389.64	-196.76
		(5.42)	(-.23)	(5.62)	(-4.54)	(-1.81)
			P_1	P_2	Y_1	Y_2
Demand	z_2	397.06	-.0004	-.0016	.3018	-.0833
		(6.88)	(100)	(100)	(.21)	(-1.49)

Note: Ratios appear in parentheses.

market. All exogenous variables are at least marginally significant, except the percentage of multiunit structure renter attribute. All variables are of the expected signs. Looking first at the supply function, we find that among the renters of housing, management firms reduce the price of the heating quality characteristic by $197. Owner-occupiers can provide their heating quality at a price averaging $390 less than that paid by renters to the owners of this house. Turning to the demand side of this market, we find the elasticity of demand for heating quality equal to -.31, evaluated at the mean. Blacks demand a very small amount less, .08 units, on the 1 to 5 scale of heating quality, less for each percentage increase in Black persons in the population, than non-Blacks. While statistically insignificant, persons who prefer multiunit structures demand greater heating quality. Every percentage increase in the number of multiunit structures on the census block leads to a 0.3 percent increase in the quality of heating demanded.

The Durham data are less than adequate for the estimation of this housing market model. The spirit of the analysis and econometrics, however, are revealed through the estimation which employed the Durham Urban Observatory data set. With characteristic supply and demand curve estimates, local government decisionmakers (or house owners) can determine the optimal quantity and tax price (quantity and price) necessary to attain their explicit objective. If they seek to maximize consumer surplus or the sum of producer and consumer surplus (or maximize profits) quantitative price and quantity of characteristic solutions may be computed with the demand and supply curve estimates based on the preceding model. Further research in this area is of paramount importance. The model requires an examination with a more complete data set. Also, the public sector characteristics supply model should be further developed. The model presented in this paper provides a new foundation for future housing characteristics research.

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An Application of Microdata for Forecasting Aggregate State and Local Government Expenditures and Employment

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INTRODUCTION AND SUMMARY

The development of any model is conditioned by the intended use of the model and constrained by available data. The model described in this paper is intended to serve as a submodel in a medium to long-term projection system operated by the Office of Economic Growth in the U.S. Bureau of Labor Statistics. The Office of Economic Growth projects industry outputs and employment using an input-output model which is driven and controlled by an econometric model of the aggregate economy and some submodels which provide more detailed demand projections in specific areas.[1] The model of consumer expenditures by Houthaker and Taylor (see reference 12) was originally developed as one of the demand submodels for the economic growth model. The model discussed here is intended to serve an analogous role for State and local government demand.

The role of the model in the economic growth system imposed two important constraints on the model's design. First, it is of primary importance that the model be able to reflect the determinants of long-term movements in State and local expenditures. Second, the model should provide projections in enough functional and object detail to assist in the allocation of State and local government demand to producing industries in the input-output final demand vectors. Both considerations dictate a considerable degree of functional disaggregation (such as education, highway, welfare, etc.), and also some object disaggregation, that is, current outlays, capital outlays, and compensation of employees.

The resulting model contains behavioral equations for 47 different items of State and local government activity. These include expenditures and employment equations for the following functions:

Elementary and secondary education	Natural resources
Higher education	Police
Other education	Fire
Highways	Sanitation
Health and hospitals	Public welfare
Sewerage	Local parks and recreation
Water utilities	General control
Other utilities	Financial administration
	Other general expenditures

[1] For detailed projections to 1985 and a discussion of the models, see reference 29. These projections have since been updated and the results summarized in Bowman and Morlan (see reference 6).

The first eight functions are estimated separately for current and capitals outlays, with an additional equation for all other capital outlays. Also included in the model are equations for total interest payments and debt outstanding with separate interest payment equations for the two utilities categories.

Although this paper attempts to summarize the development and characteristics of the State and local demand model, a more detailed discussion is presented in my doctoral dissertation from which this paper is drawn (see reference 16).

DATA AND ESTIMATION PROCEDURES

The data base used to estimate the equations of the model consists of a time series of cross sections. The microunits are States and the time series includes 11 years from 1961 to 1971. The basic expenditure data is taken from the annual Census Bureau publication, State Government Finances in 1974 (74-No. 3), and includes data for 50 States and the District of Columbia. The employment data is full-time equivalent employment as published annually by the Census Bureau in Public Employment in 1974 (74-No. 1).

Although the model is estimated with expenditures by State, the objective is not to project expenditures by State, but to project aggregate expenditures of all State and local governments in the United States. A convenient property of the data base used is that the microunits sum to the aggregate desired for projections, thus, there is no problem of whether the microunits are representative of the aggregate.

The choice of a time series and cross section data base is primarily the result of a need to expand the information content of the data base. Severe collinearity in the aggregate time series relating to State and local government expenditures frustrates attempts to derive reliable long-term projection equations on that basis. The cross sectional dimension adds a great deal of variation to the data. The presence of both time series and cross section variation captures the advantages of each type of data while overcoming their individual problems. Specifically, cross sectional data is conventionally regarded as reflecting long-term relationships. This is a desirable characteristic for long-term projection equations, but, at the same time, the presence of a time series dimension prevents extrapolation of the possible abnormalities of any one year of cross sectional data, enables one to identify trends which would not be evident in a purely cross sectional data base, and facilitates the use of variables which may not vary across States or for which data are not available by State.

The use of time series and cross sectional data combined is not without precedent. It has been applied in many areas of study, including production (see reference 18), investment (see references 13, 27, and 31), demand (see references 2 and 9), and State and local government (see references 8 and 22). Unlike the present study, most of these were designed to shed light on theoretical hypotheses or to illustrate various estimation techniques. The primary concern here is to derive projection equations for a medium to long-term interval.

The model is estimated equation by equation, not as a system, but by applying ordinary least squares (OLS) to the entire set of observations. Thus, each observation has the form "Y_{st}." where "s" is the State and "t" is the year of the observation. Therefore, in the usual ordinary least squares (OLS) notation, "Y," the vector of observations on the dependent variable, would be of dimension (ST X 1). In the basic data, "S" equals 51 States and "T" equals 11 years, thus, "Y" is (561 X 1).

As mentioned above, the microunits in the data sum to the aggregate U.S. values. Therefore, if the equations were to be estimated for expenditures or employment it would be appropriate to give each State equal weight in the regressions. However, the equations were all estimated in per capita form in order to reduce cross sectional collinearity. In this case, aggregate U.S. per capita values are a weighted average of individual State per capita values. Since State observations are weighted equally in the regressions, an aggregation bias could arise. Weighting the observations to account for this problem has the effect of reintroducing cross sectional collinearity, so an alternative means of adjusting for possible bias was used. This consisted of adding an observation to the data in each year for the aggregate U.S. per capita values.

These additional observations increase the total number of observations to 572. To test for the presence of bias, an intercept dummy was applied to the aggregate U.S. observations. In the final set of equations none of these intercept dummies proved significant based on their standard errors, however, they frequently improved the characteristics of the equation in simulating the aggregate U.S. time series and are thus used to adjust the equations in many functional areas.

The aggregate U.S. observations also provided an opportunity to test the slope parameters estimated from the pooled data to see if they were appropriate for forecasting the aggregate time series. Initial tests revealed that the slope dummies were insignificant, but that a time trend dummy frequently improved the simulations of the aggregate U.S. time series. Thus, in many equations slight adjustments are retained to account for these trend effects.

In estimating projection equations from time series data, the characteristics of the estimated equation, such as coefficients of determination and standard errors of the estimates or Durbin-Watson statistics, are directly appropriate for evaluating the probable performance of the model in its intended use. It is important to recognize that this is not the case in the present study. This fact was considered in the method of evaluating regression results. In addition to the usual evaluation of the coefficients for theoretical reasonableness, significance, degree of sensitivity to equation specification, and evaluation of the usual regression fit measures, an analysis was made of the ability of the equations to simulate the aggregate U.S. time series. The residuals from these simulations were analyzed using several measures including average absolute percent errors, root mean square errors, bias, and residual patterns. The performance of the equations in these tests were an important factor in selecting the final equations.

Estimation of the equations by OLS may not result in minimum variance estimates of the coefficients. This is a well known result, based on the probable characteristics of the error term, and many approaches to obtaining minimum variance estimates from a time series/cross section data base have been investigated in the literature.[2] However, OLS estimation does produce unbiased estimates if lagged dependent variables do not appear in the equation specification.

In selecting an estimation method the various alternatives were compared on three bases: (1) Comparative performance based on available studies and experimentation with State and local government data, (2) theoretical considerations of the variations which influence the different estimates, and (3) the practicality and cost of the various techniques.

Three studies have appeared comparing various estimators for pooled time series and cross section data in Monte Carlo experiments. Two studies by Nerlove (see references 19 and 20) were for dynamic specifications. Since most of the State and local equations do not contain lagged dependent variables, a study by Maddala and Mount (see reference 15) is most relevant. They compared 11 different estimators for a static specification with only cross sectional error components specified. As expected, their results depend on the relative size of the error components. In cases where the cross sectional error component was about as large as the residual component, ordinary least squares (OLS) coefficients performed poorer based on root mean square errors than did covariance estimators or the various generalized least squares (GLS) procedures. Among the covariance and GLS estimators, no particular method was shown to be better than the others. As the relative cross section error component was decreased, the OLS estimators became comparable in performance to the others.

Cross section and time series error components were computed for the State and local equations. They were estimated from OLS residuals as proposed by Wallace and Hussain (see reference 30). In most cases the cross sectional error components were large enough to indicate that the variance of the coefficients could be reduced by using covariance or GLS estimation. However, when coefficients were estimated from a covariance transformation for some education equations, they were found to simulate the U.S. per capita time series less accurately than the OLS equations. Since the model's objective is to forecast the U.S. data, this was a serious drawback.

In considering the various estimators from a theoretical point of view, some judgments can be made based on what variations they take into account in deriving coefficients. For example, although, covariance transformation estimates are more efficient than OLS, they ignore some of the most relevant sources of information in the data. In order to see this, it must be recognized that the covariance transformation

[2] For examples of such studies see Amemiya (reference 1), Balestra and Nerlove (reference 2), Henderson (reference 11), Nerlove (reference 21), Rao (reference 25), Swamy (references 27 and 28), and Wallace and Hussain (reference 30).

amounts to subtracting from each observation its corresponding time series and cross section means and adding back the overall mean. Thus, the variance explained by covariance transformation estimates is the variance of each observation about its individual mean; it does not explain differences in the means, which is the more relevant question for this model. GLS estimators weight the information implicit in the variation from time series/cross section and overall means in inverse proportion to their respective variances. By contrast, OLS implicitly weights the information contained in the data according to the number of observations. Since the State and local government data are prone to have a large cross sectional error component relative to their residual error component, the cross sectional variations would receive a relatively small weight in the estimation. Since it is expected that differences in cross sectional means will reflect important long term reactions, it may not be desirable to give it such a small weight.

From a practical point of view, the use of GLS requires the estimation of error components. Most techniques which have been proposed involve some sort of two-stage process based on OLS estimates of individual time series for each microunit or of individual cross sections for each year. Unbiased estimates of cross section and time series error components are derived from these in order to estimate the error covariance matrix.[3] With 572 observations to contend with, the estimation of a GLS model becomes relatively costly and time consuming with only questionable increases in benefits for the purposes of this model.

Having taken the above considerations into account, it was decided that ordinary least squares would be an appropriate method of estimating the State and local government equations.

DESCRIPTION AND EVALUATION

The constituents of State and local government form preferences for public goods in much the same way they form preferences for private goods. However, the translation of these preferences into effective demand is much different in the public sector. In the private sector, aggregate demand may be derived by adding up individual effective demands as expressed in the market. In the public sector, individual preferences must be aggregated, or in many cases averaged, through the political process before demand is made effective. The study of such political processes is known as the theory of public choice. A review of this literature was published recently by Mueller (see reference 17). Perhaps the best known work in the field is a book by Buchanan and Tullock (see reference 7). Recent applications to State and local government demand include studies by Barr and Davis (see reference 3), Bergstrom and Goodman (see reference 4), and Borcherding and Deacon (see reference 5). This study does not attempt to postulate a theory of public choice in the sense that these other studies have. Rather, the objective here has been to describe the outcome of such processes and to identify the basic determinants of those outcomes. The demand functions derived in the State and local studies cited above can, under a certain set of assumptions, be interpreted as individual demand functions for the median voter. The functions of this model must be considered aggregate per capita demand functions.

The variables explaining expenditures in this model do not differ greatly from those which appear in median voter demand functions. The primary difference is that this model does not include any measure of individual tax shares for the median income citizen. Instead, total cost is taken to be essentially the same as expenditures in the aggregate and the distribution of the tax burden does not affect total demand directly.

Four types of variables affect the demand for State and local government expenditures in the model. These can be described as: (1) Income, (2) demographic characteristics, (3) grants-in-aid received from the Federal government, and (4) other economic variables. Income, measured by per capita personal income, is the primary determinant in the model and enters most of the expenditure equations either in the current year, lagged one year, or as a change. Personal income is adjusted slightly by subtracting the current year interest payment obligation of the State and local governments. This adjustment introduces a very minor simultaneity into the model because interest payments are determined by capital outlays in the various functional areas which are either directly or indirectly a function of the income variable.

Demographic variables include the age distribution of the population, measures of the geographical distribution of population, median education levels, and existing highway mileage. Grants-in-aid are included to measure effects exerted from outside a State on the level of expenditures. Other economic variables include unemployment rates, interest rates, and relative prices. The latter are represented by a proxy consisting of the relative compensation rates for public and private employees.

Space does not permit presenting individual equation estimations. Instead, some attempt is made to summarize the results. Elasticities in the model were calculated by simulating the effects of changes in the determinants in 1973. In this way, not only individual equation elasticities are generated but also those due to the interaction which takes place among equations. These interactions result from the effects of current outlays on capital outlays, and both of these in turn affecting employment. Other interactions include the effects of total nonadministrative expenditures on expenditures for general control and financial administration and the effects of capital outlays on debt and interest payments.

The simulated income elasticity of total general expenditures is .76 based on a change in current year personal income. Current account outlays have a .83 elasticity, while capital outlays have only .48 elasticity. This is because most capital outlays are more sensitive to lagged income or other delayed effects. The income elasticities of individual functions show

[3] See for example, Nerlove (reference 18) or Zellner (reference 39).

considerable variation. Expenditure elasticities with respect to a change in 1973 personal income are shown in table 1. These must be considered partial effects since a one year change does not capture lagged effects and may distort some of the results. The income elasticities for general expenditures range from .225 for higher education to 1.481 for other general expenditures. The particularly low value for higher education is due to the presence of median education levels as an explanatory variable in the equations. Its correlation with personal income diminishes income's role. The negative elasticity observed for water utilities is the result of income entering the capital outlays equation in first difference form with a negative sign. For a one year change, not only is the change exaggerated, but there would be a partially offsetting reduction the following year. The result is that the elasticity of current year water utilities expenditures to a change in income in the lagged year is .375.

Although direct comparisons with other studies are not easy, the results do seem to be consistent with other findings. Borcherding and Deacon (see reference 5) show elasticities under various assumptions for their model. Their income elasticities appear to be quite sensitive to equation specification. For five of their eight categories the elasticities of this model fall within the range of their elasticities. Health and hospitals and police are the only two functions where the results seem significantly different. Borcherding and Deacon's elasticities are lower for health and hospitals and higher for police protection. Bergstrom and Goodman (see reference 4) show income elasticities for police and parks and recreation, .71 and 1.32 respectively, which seem to be roughly consistent with the results of this model.

Table 1. **Selected Simulation Elasticities**

Expenditure items	Income	Urban-ization	Relative compen-sation
Total general expenditures	.762	-.067	-.023
Local education	1.031	-.092	-.150
Higher education	.225	-.372	(NA)
Other education	1.184	-.644	.356
Highways	.430	-.439	(NA)
Natural resources	.475	(NA)	(NA)
Police	.594	.365	.119
Fire	1.173	.474	(NA)
Sewerage	.357	.042	(NA)
Sanitation	.374	.643	(NA)
Health and hospitals	.714	.278	.100
Public welfare	.371	(NA)	(NA)
Parks and recreation	1.022	.580	(NA)
General control	.911	.047	-.027
Financial administration	.890	-.082	-.026
Other	1.481	(NA)	(NA)
Water utilities	-.073	.312	(NA)
Other utilities	.899	(NA)	(NA)
Interest	.066	(NA)	(NA)

NA Not available.

A comparison of estimated income coefficients from some other studies of per capita expenditures with ratios of expenditure to income change, calculated from simulations of the model, show a general agreement. Table 2 shows such comparisons with two studies for available functions. O'Brien's results for three different estimation methods are based on a time series and cross sectional data base similar to the one used in this study. The Sacks and Harris results are based on a 1960 cross section of States. At the functional level the results seem quite consistent. For education, highways, and health and hospitals, the model simulations are more consistent with O'Brien's generalized least squares results. It is interesting to note the difference between the model's results and O'Brien's for public welfare. O'Brien estimates expenditures net of Federal grants, so that the difference in coefficients do not necessarily imply different elasticities in O'Brien's equation and the model, and in fact, a rough calculation showed O'Brien's elasticity to be about .34 compared to the model's .37. Similar problems exist in comparing the other functions, but grants are not as large a share in most functions as they are in public welfare.

The demographic variables in the model play an important role in determining the mix of expenditures among functions of State and local government. Age distribution of the population affects local education, higher education, and health and hospitals expenditures with elasticities ranging between .182 and .362. The geographic distribution of population was measured by three distinct variables, the percent of population living in urban areas, population density, and the share of highway mileage located in municipal areas. Of these three, urban population proved most useful and the elasticities are shown in column 2 of table 1. The directions of these elasticities are interesting because they cannot be determined *a priori* due to the offsetting effects of scale economies and demand for services related to urban environments. Negative effects were obtained for education, highways, financial administration, and the other general expenditures category. Categories which have a positive effect include those functions which tend to reflect urban services such as, sewerage, sanitation, fire protection, police protection, water utilities, parks and recreation, and health and hospitals. The other two measures had significant effects on only a few equations and their elasticities were very small. As mentioned above, median educational attainment has a strong effect on higher education expenditures with an elasticity of 1.58. The remaining variable which was classified, somewhat arbitrarily, as demographic was the stock of highway mileage. It exerts a positive influence on current account outlays for highways, reflecting increased maintenance and administration requirements.

The three variables classified as other economic variables are interest rates, unemployment rates, and relative compensation as a proxy for relative prices. The use of yields on State

Table 2. **Change in Expenditures Per Dollar Change in Income**

Expenditure items	O'Brien[1]			Sachs and Harris[2]	Model simulation
	Ordinary least squares	3-stage least squares	Generalized least squares		
Total general expenditures....	.128	.102	.117	.099	.134
Education.....	.050	.053	.055	(NA)	.056
Local education.....	(NA)	(NA)	(NA)	.037	.049
Highways.....	.017	.015	.008	.014	.008
Health and hospitals.....	.008	.007	.009	.008	.009
Welfare.....	.004	.004	.003	.011	.009
Police.....	(NA)	(NA)	(NA)	.003	.004
Fire.....	(NA)	(NA)	(NA)	.002	.003

NA Not available.
[1]See reference 22.
[2]See reference 26.

and local government securities does not appear in most State and local expenditure studies, because it is not available in cross section by State. The presence of a time series dimension in the model's data base allows it to affect the equations even though it cannot affect the explanation of the cross sectional variations. It has the expected negative influence on capital outlays in local education, sewerage, water utilities, other utilities, and health and hospitals. In the residual capital outlays equations it has a fairly strong positive effect. The reasons for this result are not clear but some possible explanations include, substitution of funds from functions which require greater debt financing, increased need for public housing which is a fairly large portion of the residual capital category, or a relatively large portion of small capital outlay items financed by Federal grants. This latter factor probably accounts for the lack of sensitivity of highway capital outlays to yields on State and local securities.

Unemployment rates directly affect only public welfare and other general expenditures. The elasticities are not large, .039 and .083, respectively. These findings are in agreement with the usual assumption that State and local expenditures are not strongly cyclical in nature.

The effects of relative compensation on expenditures are neither very significant nor unambiguous to interpret. Elasticities are shown in column 3 of table 1. The elasticities were generated by assuming an increase in the compensation rates for State and local employees. The net effect is to reduce total general expenditure with -.023 elasticity, but for some functions there is an increase in expenditures. This result implies an inelastic demand for State and local employees in those areas, or possibly that the compensation rates of that functional category are not representative of the aggregate education or noneducation rates used in the model. Data are available for compensation rates in each function and the use of such function specific rates should facilitate interpretation of the results in future work on the model.

The remaining category of determinants is Federal grants-in-aid. As a determinant of State and local activity they have received far more attention than the others in the literature. The measure of grants used is grants received by State and local government. Although more conceptually appropriate for the model, considerable function detail is lost by using the intergovernmental revenue data instead of intergovernment expenditures of the Federal government which are available in more detail. The usual evaluation of the effect of grants on expenditures depends on the grant being measured for the specific function being investigated. In table 3, simulations of the change in expenditures per dollar of change in Federal grants are shown for roughly matching functional categories. The results of selected other studies are also shown for comparison. The change in total general expenditures resulting from a $1 change in grants, proportionately distributed among the grant categories in the model, is $1.746. This is in general agreement with most cross section findings. In the empirical evidence reviewed by Gramlich (see reference 10), comparable cross section coefficients averaged 1.79, while comparable time series results averaged .85. O'Brien's results are slightly lower at 1.515 for OLS estimates and 1.560 for GLS estimates. As shown in table 3, the model's simulations for specific functions are generally closest to O'Brien's GLS estimates and generally lower than the studies using pure cross sectional data by State. The exception to this is health and hospitals. The model simulation results in an implied coefficient of 3.900, while O'Brien's GLS coefficient would be only .96. There is considerable variation in the grants coefficient for health and hospitals among various other estimates also. For example, Pogue and Sgontz (see reference 24) obtained estimates ranging from 1.973 to 9.561 in separate cross sectional estimates for the years 1958 through 1964. The implications of grants-in-aid coefficients have been well discussed in the literature and will not be reiterated in this paper.

The employment equations in the model are based on a conceptual identity which states that employment is equal to compensation divided by compensation per employee. In algebraic terms, $E = AX/P$, where "E" is employment, "X" is

Table 3. **Implied Coefficients of Grants-In-Aid for Selected Functions**

Expenditure items	Model simulation	Ordinary least squares	O'Brien[1]		Pogue and Sgontz[2]	Osman[3]	Sachs and Harris[4]
			3-stage least squares	Generalized least squares			
Direct general expenditures.	1.746	1.515	2.370	1.560	1.807	1.936	1.760
Education	2.039	2.640	2.180	2.090	4.032	5.114	(NA)
Highways	1.111	1.037	1.387	1.067	1.450	1.374	1.259
Health and hospitals	3.900	1.674	2.110	.960	4.464	2.087	2.355
Public welfare	1.217	1.528	1.509	1.149	1.578	1.376	1.683
Natural resources	3.636	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)
Police	[5]3.225	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)

NA Not available.
[1]See reference 22.
[2]See reference 24.
[3]See reference 23.
[4]See reference 26.
[5]Law enforcement assistance administration grants.

total expenditures, "A" is the compensation share of expenditures, and "P" is pay per employee. "A" may be a constant, but in most equations it is allowed to change as a result of relative wages or the share of capital outlays in total expenditures. All but two of the employment equations were estimated in log linear form as implied by the multiplicative identity. It is expected that the coefficients on total expenditures will be positive and coefficients on pay per employee will be negative. Further, if the compensation shares are adequately accounted for by the intercept and the special variables mentioned above, and if the level of compensation per employee used is appropriate for the functional category being explained, then the sum of the expenditures and pay coefficients should approximate zero.

The employment equations' coefficients have been tabulated in table 4. The expenditure and compensation coefficients are all highly significant and of the expected sign. In the last column on the right the sum of the expenditure and compensation per employee coefficients have been computed. As can be seen, the sum is actually quite close to zero in many

Table 4. **Summary of Employment Equation Coefficients**

Employment category	Intercept (1)	Total expenditures (2)	Compensation rate (3)	Relative compensation (4)	Capital shares (5)	Grants-in-aid (6)	Time (7)	Col. 2 plus col. 3 (8)
Local education	9.97	.65	-.59	-.14	-.10	(NA)	.04	.06
Higher education	9.99	.93	-.84	(NA)	-.01	(NA)	(NA)	.09
Other education	12.20	1.30	-1.27	-1.10	(NA)	(NA)	-.39	.03
Highways	8.82	.82	-.75	.24	-.71	(NA)	(NA)	.07
Natural resources	13.95	1.38	-1.71	.52	(NA)	(NA)	(NA)	-.33
Police	9.11	91	-.65	(NA)	(NA)	(NA)	(NA)	.26
Fire	10.64	.96	-.93	.20	(NA)	(NA)	.02	.03
Sewerage	6.79	.63	-.44	(NA)	-.72	(NA)	(NA)	.19
Sanitation	12.88	1.19	-1.37	-.31	(NA)	-.05	.10	-.18
Health and hospitals	10.67	.89	-.90	-.17	-.05	(NA)	.03	-.01
Public welfare	6.37	1.50	-.39	-.27	(NA)	-.95	.18	.16
Parks and recreation	10.38	.94	-.94	.15	(NA)	(NA)	(NA)	0.00
General control	7.45	.66	-.31	(NA)	(NA)	(NA)	.01	.35
Financial administration	10.12	.89	-.79	(NA)	(NA)	(NA)	-.02	.10
Other general expenditures	(Nonlog equation)							
Water utilities	8.86	.66	-.72	(NA)	-.26	(NA)	.03	-.06
Other utilities	(Nonlog equation)							

NA Not available.

instances, especially in categories with special variables included to account for changing compensation shares. The public welfare sum was calculated after netting out the coefficient on grants for public welfare. Grants were included in the employment equation to account for the fact that most of these grants are directly transferred to recipients and include no compensation. All the capital outlay shares have negative effects as expected, but the effects of relative compensation rates are mixed. In some cases this may be the result of the compensation rate not being appropriate to the specific category in question. Another possible explanation of positive signs is that the causation may be running in the other direction—that is increased employment may be responsible for increasing State and local compensation rates.

The debt and interest sector is somewhat different from the expenditure equations. Outstanding debt is determined by the level of debt in the previous year, the yield rate of State and local government bonds, and capital outlays in separate functional areas. Total interest payments are determined by the same variables, but the yield rate has a positive effect on interest payments, instead of a negative effect as it has on debt.

EVALUATION OF MODEL PERFORMANCE

The performance of the model has been evaluated in terms of its ability to simulate aggregate expenditures and employment by function for the sample period, 1961 to 1971, and for two post sample years, 1972 and 1973. Trial projections were also made through 1985. In this section the results of these tests are summarized, but more detailed evaluations are shown in Morlan (see reference 16).

Table 5 contains some results from the estimation and simulation of the model. The first two columns are based on individual equation tests. The last three are based on simulation of the model as a set of equations, so that, for example, expenditure equation results feed into the employment equations.

Column 1 shows coefficients of determination from the estimation of the equations from the pooled time series and cross section data, thus reflecting the equations' abilitites to explain cross sectional variation as well as time series. Column 2 shows average absolute percent errors for a time series simulation of national per capita data only. The coefficients in column 1 reflect the relative difficulty of capturing the variability of capital outlays in most functions. Highways are an exception to this rule only because of the influence of grants-in-aid. In most functions, it appears to be the volatility of capital outlays within States that makes it difficult to explain even when given current outlays. However, one exception to this is other utilities. In that function the equation can explain very little of current outlays variation, but given current outlays the capital equation is moderately successful. Equations which performed poorly in explaining cross sectional and time series variation often perform quite well for the aggregate per capita simulation shown in column 2. An extreme example is again provided by current outlays for other utilities, which explained less than 5 percent of the pooled variation but had an average absolute percent error of only 2.2 percent in column 2. However, column 2 continues to reflect the relatively poorer performance of the capital equations.

Column 3 of table 5 shows average absolute percent errors (AAPE) over the sample period for model simulation. Columns 4 and 5 show actual percent errors for the post sample years, 1972 and 1973. In model simulations the results of various aggregates or identities become available. The AAPE for total general expenditures was 1.73 percent. It is interesting to note that the AAPE for capital outlays is only 0.92 percent, indicating that individual capital errors had a tendency to offset one another during the sample period and also that larger errors occurred in smaller expenditure categories. An unweighted average of the AAPE's for the seven general capital equations individually would yield 6.34 percent. The most troublesome category was other education which is fortunately a small part of the total.

In column 2 of table 5, the results of simulation as a set of equations as opposed to individual equations were analyzed in terms of root mean square errors. From the total of 47 estimated equations, 29 performed better in the model simulation than as individual equations, 13 performed worse, and 5 remained unchanged. Thus, errors in current outlays estimates do not appear to build up in the capital or employment equations.

The percent errors in columns 4 and 5 are based on one of several alternatives which were used. The need for the alternatives arose from the beginning of revenue sharing which substantially modified the grant relationships built into the model's structure. The problem is complicated by the fact that in fiscal 1973, State and local governments received one and a quarter years of revenue sharing funds all in the last half of the year. Any impact which could be measured in 1973 would not be the expected impact of an established revenue sharing program. In the post sample simulation shown in columns 4 and 5 of table 5, general revenue sharing was treated as if it were an addition to personal income. Other simulations treated it as an increase in conventional grants, or as some combination of income and grants. Treatment of revenue sharing as an increase in personal income gave the best overall results for 1973, although not necessarily for every individual function.

In addition to the revenue sharing problem, there were other major shifts in emphasis in State and local activity toward the end of the sample period and in the post sample period. These included major changes in the trends of school age population and a major policy thrust toward solving environmental problems. This policy shift, in addition to shifting resources toward environmental areas, at least temporarily shifted them away from the emphasis on highway construction.

The impact of these factors are evident in the 1972 and 1973 errors. Current outlays and employment for total general expenditures are simulated very well, but capital outlays were seriously overpredicted by nearly 13 percent in 1973. The

Table 5. **Selected Results From Estimation and Simulation of the Model**

Category	Individual equations		Model simulations		
	Coefficient of determination (1)	Sample period average absolute percent errors (2)	Sample period average absolute percent error (3)	1972 percent errors (4)	1973 percent errors (5)
Total:					
General expenditures	(NA)	(NA)	1.730	-.910	2.608
Current expenditures	(NA)	(NA)	2.072	-1.983	.423
Capital expenditures	(NA)	(NA)	.915	3.740	12.943
Employment	(NA)	(NA)	.780	1.755	.648
All education:					
Total expenditures	(NA)	(NA)	2.993	-3.371	1.237
Current expenditures	(NA)	(NA)	3.717	-5.258	-2.007
Capital expenditures	(NA)	(NA)	1.594	9.978	26.453
Employment	(NA)	(NA)	1.323	1.125	-.544
Local education:					
Total expenditures	(NA)	(NA)	2.822	-3.022	2.167
Current expenditures	.824	2.974	2.957	-4.162	.080
Capital expenditures	.478	4.035	3.942	6.777	21.048
Employment	.845	1.348	1.000	2.053	.834
Higher education:					
Total expenditures	(NA)	(NA)	4.717	-2.961	-.776
Current expenditures	.695	6.817	6.815	-7.135	-7.886
Capital expenditures	.418	8.596	8.596	15.446	36.958
Employment	.914	2.151	5.567	-3.184	-6.308
Other education:					
Total expenditures	(NA)	(NA)	8.661	-10.220	-1.766
Current expenditures	.483	9.645	9.617	-12.175	-4.025
Capital expenditures	.154	12.889	15.104	7.292	19.334
Employment	.846	7.790	10.170	9.071	4.126
Highways:					
Total expenditures	(NA)	(NA)	1.712	-1.568	7.010
Current expenditures	.645	1.988	1.975	-2.422	2.495
Capital expenditures	.927	1.922	1.922	-1.104	9.828
Employment	.804	1.099	.764	2.071	3.642
Natural resources:					
Total expenditures	.584	3.735	3.732	8.785	14.519
Employment	.965	6.587	2.919	-8.623	-8.802
Police:					
Total expenditures	.830	2.799	2.790	1.104	7.822
Employment	.929	1.290	1.626	7.627	12.798
Fire:					
Total expenditures	.711	1.908	1.890	-2.287	2.321
Employment	.858	1.701	1.234	2.167	.732
Sewerage:					
Total expenditures	(NA)	(NA)	5.089	-.993	11.659
Current expenditures	.768	2.313	2.297	-8.490	-8.769
Capital expenditures	.297	8.051	8.051	2.851	21.556
Employment	.430	1.950	2.246	6.202	4.055
Sanitation:					
Total expenditures	.697	2.977	2.977	-10.901	-14.522
Employment	.758	3.564	5.129	-2.946	-14.049

NA Not available.

Table 5. **Selected Results From Estimation and Simulation of the Model**—Continued

Category	Individual equations		Model simulations		
	Coefficient of determination (1)	Sample period average absolute percent errors (2)	Sample period average absolute percent errors (3)	1972 percent errors (4)	1973 percent errors (5)
Health and hospitals:					
Total expenditures	(NA)	(NA)	2.249	-4.976	-1.553
Current expenditures	.663	2.443	2.430	-5.364	-3.644
Capital expenditures	.335	4.433	4.433	-1.136	23.534
Employment	.853	1.204	1.308	-1.241	-6.044
Public welfare:					
Total expenditures	.807	2.418	2.411	3.178	4.204
Employment	.539	3.715	2.047	5.761	4.742
Parks and recreation:					
Total expenditures	.577	3.854	3.842	-8.230	-6.696
Employment	.801	2.350	1.437	-3.468	-4.996
General control:					
Total expenditures	.797	.811	2.289	-1.800	-1.270
Employment	.571	1.881	.993	2.965	-.395
Financial administration:					
Total expenditures	.730	1.196	1.900	1.381	.866
Employment	.741	1.774	1.804	7.705	4.644
Other general expenditures:					
Total	.663	3.296	3.303	10.577	9.036
Employment	.627	3.166	3.752	3.988	7.632
Other capital functions:					
Total expenditures	(NA)	(NA)	1.357	2.447	3.117
Current expenditures	.369	2.558	2.548	5.981	1.047
Capital expenditures	(NA)	(NA)	1.376	1.990	3.387
Water utilities:					
Total expenditures	(NA)	(NA)	2.883	-2.128	-5.122
Current expenditures	.509	2.959	2.952	-5.781	-8.281
Capital expenditures	.096	6.709	6.702	3.943	1.074
Employment	.269	1.772	1.443	1.699	-3.879
Other utilities:					
Total expenditures	(NA)	(NA)	2.848	-.369	-4.630
Current expenditures	.050	2.785	2.768	-9.978	-9.191
Capital expenditures	.533	9.308	9.309	24.299	2.730
Employment	.704	1.704	1.775	7.614	10.838
Interest expenditures:					
Water utilities	.907	2.155	2.251	-4.553	-9.260
Other utilities	.974	3.071	3.758	-5.130	2.496
General	(NA)	(NA)	2.914	-14.701	-17.573
Total	.947	2.543	2.543	-13.369	-15.695
Nonadministrative and noncontrol expenditures	(NA)	(NA)	1.732	-.927	2.721
Total debt outstanding	.779	1.077	1.093	.193	2.856

NA Not available.

most significant part of this error comes from educational capital. The slowdowns in enrollment, or some other factors, had a dramatic impact on capital outlays in the early 1970's, far beyond what was embodied in the model's equations. However, the capital outlays slowdown was also more general than just educational. Capital outlays in 1973 were seriously overpredicted for highways, sewerage, and health and hospitals as well. However, the 1972 estimates of these were quite reasonable. One plausible explanation of the general shortfall in actual capital outlays for 1973 relates to revenue sharing. It seems plausible that capital projects may have been delayed in 1973 in anticipation of revenue sharing funds. Once the funds were received late in the year the leadtime on construction projects would have prevented the money showing up as capital expenditures. The presence of considerable inflation and high interest rates would have made delay of capital projects even more tempting. Verification of this hypothesis will require further years of data.

The current outlays equations for education do not reflect the problems of the capital equations. If anything, there is a tendency to underpredict current outlays for education. For sanitation expenditures the impact of environmental policy seems quite evident. The equations underpredict expenditure from 1970 and beyond. Similar effects are evident in current sewerage outlays and water utility outlays, although not for capital outlays in those areas.

The simulations of debt outstanding are quite reasonable in 1972 and 1973; however, the interest payments are seriously underestimated. The fact that capital outlays are overestimated would lead one to expect the same for interest payments. In the absence of large errors in the debt equation these results are difficult to explain. A preliminary test on 1974 data indicates that the estimate for total interest continues to be near 16 percent. This may indicate some shift in relationship, not captured by the equation, between debt outstanding and the level of interest payments.

In making a trial projection to 1985, the model seemed to produce reasonable results in terms of growth rates, State and local expenditures relative to personal income, and relative importance of various functional categories. Space does not permit analysis of these results, and the reader is again referred to Morlan (see reference 16) for a discussion of these. These projections were only a preliminary test and further work is needed to evaluate the model completely.

CONCLUSIONS

There are opportunities for further improvements to the model and for further evaluation of its results. These include incorporating additional years into the data base, to reflect significant changes which have taken place since 1971 in the structure of Federal aid, the use of more detailed functional data on grants-in-aid, the use of detailed functional compensation data instead of only educational and noneducational compensation, and also the use of a revised personal income series by State made available since the model was estimated.

Although some specific questions about the model's performance in certain areas remain, the applicability of combined cross sectional and time series data to long-term forecasting has been demonstrated.

Incorporation of the model into the BLS economic growth projection system requires conversion of the expenditure results to the national income accounts' concept of purchases of goods and services and deflating to constant dollars. Work on these conversions are underway and should be completed soon.

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Comments on the Estimation of Local Government Finances

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The purpose of my remarks is to comment on the three papers presented to the American Statistical Association session on "Estimation of Local Government Finances." The three papers are quite different, although all are empirical. They vary in terms of the subject matter and issues addressed, the statistical treatment, the availability of data, and the emphasis on forecasting versus understanding the structure of the public sector area. My remarks will address each paper in turn, summarizing the main findings and pointing out what I believe to be the major difficulties of each paper. I might add that, to keep my remarks brief, I have concentrated on criticism rather than praise, but I found all three papers very useful contributions to the empirical exploration of the public sector. The final section of my remarks summarizes what I consider the major policy implications of the three papers.

LEE AND LIU

The paper by Lee and Liu, entitled "An Econometric Model of Metropolitan Growth with Endogenous Local Finances" analyzes the impact of the local government sector on regional growth. In particular, the paper investigates the impacts that expenditure and taxing decisions undertaken by local governments have on migration and employment growth. The paper develops a five-equation structural model, in which the net migration rate, employment change, change in per capita local government expenditures on health and education, change in per capita local government expenditure on other public services, and change in average local tax rates are endogenous variables. This model was estimated by three-stage least squares, using data for 51 SMSA's between 1960 and 1970. Lee and Liu found that increased expenditures on health and education encouraged migration, while increased tax rates discouraged migration and employment growth. However, greater expenditures on other public services were found to discourage employment growth, contrary to expectations, although the coefficient was statistically insignificant. Lee and Liu also found that migration rates and employment growth are closely related to one another. The authors then use these empirical results to make a number of public policy recommendations, the major one being that urban areas trying to increase growth should increase expenditures for health and educational services and hold down tax rate changes. The authors expect communities to be able to do this by using Federal revenue sharing and other tax sharing devices.

While these results and policy recommendations are not surprising, they are potentially misleading. The danger is that policymakers reading the Lee and Liu paper will be led to the conclusion that tax and expenditure change will have a *substantial* effect on employment growth. While Lee and Liu demonstrate that tax and expenditure policies have statistically significant impacts on migration and employment growth, their discussion does not address the quantitative importance of tax and expenditure decisions vis-a-vis the other influences on firm locational decisions. The Lee and Liu paper would be improved greatly if it performed calculations to show the quantitative importance of the various tax and expenditure variables (beta weights, elasticities, and the like). At a minimum, the data sources and units for the variables need to be explained. For example, the migration equation indicates that expenditures on health and education increase migration while tax rate increases decreases migration. But since no units are given and no attempt is made to assess the quantitative importance of these two influences, it is impossible to determine whether an increase in educational expenditures financed by a tax rate increase would stimulate or depress migration. Since the major question addressed by the Lee and Liu paper is a quantitative one (i.e., what is the *magnitude* of the local public sector's impact on metropolitan growth), the lack of concern for interpreting the results in quantitative terms is a major inadequacy of the paper, particularly as its results are used to recommend changes in public policy.

The above remarks assume that the Lee and Liu results are correct and what is needed is to flesh out their quantitative implications. There are, however, some reasons to be skeptical of the paper's results because of the empirical strategy employed. The data Lee and Liu use to test their model are aggregated data for SMSA's, so that expenditures data are presumably average values for all the jurisdictions in the SMSA. However, if a variety of tax and expenditure possibilities are available in the jurisdictions within a single urban area, why should the *average* urban area figures affect the firm's locational decisions? It may be that Lee and Liu are correct in that tax and expenditure decisions influence population and employment growth, but that the main effect is to influence locational decisions *within* an urban area rather than *between* different urban areas. At the very least, one would want to consider State tax and expenditure policies as influences on interurban population and employment growth shifts. Thus, while it would no doubt complicate the empirical study, Lee and Liu may want to use data for individual cities and towns to test for the importance of local government finance on growth. Results from this more direct empirical test would indicate whether changes in local tax and expenditure policies would influence employment and population growth, as many central city mayors seem to believe, and what the likely quantitative importance of these effects would be.

While these remarks on the Lee and Liu paper are critical, the paper is clearly a useful beginning. It presents a framework, data base, and empirical results which can profitably be expanded on to provide important insights into the factors responsible for regional growth. Since many public officials are very interested in population and employment growth,

central city officials seeking primarily to attract people and jobs and many suburban officials seeking to discourage greater population and employment growth, the results of careful quantitative investigations of these relationships should add a good deal to important public policy decisions.

WYSE

The paper by Wyse, entitled "Toward the Measurement of the Housing Service Component of the Demand for Local Public Services," concentrates on intraurban variations in the public sector. Wyse attempts to shed light on the demand for local public goods by analyzing the price structure of the housing market. Since a homeowner purchases a package of local public services and taxes, as well as the house itself, when he purchases a home, prices established in urban housing markets should reflect households' willingness-to-pay for additional public services. A recent article by Rosen provides the framework that Wyse uses to generate strategy for estimating these household demands. Rosen's framework essentially involves a two-stage process: The first stage is to empirically determine the price structure of the housing market by estimating a hedonic housing price equation; the second stage is to use the intraurban variations in housing attribute prices revealed in the first stage to estimate demand and supply relationships for the various housing attributes. Wyse summarizes the Rosen methodology, including the identification problem which arises in separating demand and supply from one another.

While theoretically sound, the Rosen procedure involves a great many empirical complications when it is translated into empirical research. The demand and supply functions estimated in the second stage are likely to be quite sensitive to the "prices" estimated in the first stage hedonic regression; and these "prices" are difficult to estimate with confidence. For one thing, the traditional statistical problems of multicollinearity and omitted variable bias are likely to be particularly important, since it is difficult to get information on all the characteristics of housing and neighborhoods which influence housing prices. In addition, the estimated marginal prices are greatly influenced by the functional form specified for the hedonic price equation. There is the further issue of whether the urban housing market is a single housing market, or rather a series of related submarkets. If a series of distinct submarkets exist, the appropriate procedure would be to run a separate hedonic regression for each submarket and estimate separate demand and supply functions. Finally, there is the question of the dynamics of the housing market. Current prices might reflect not only current environment and neighborhood factors, such as school quality or air quality, but also expectations for future changes in the variables.

Wyse's empirical results are severely limited by the quality and quantity of his data, a fact which he readily acknowledges. The empirical evidence consists of demand and supply functions for two housing characteristics, one structural attribute (home heating quality) and one local public service attribute (fire safety). His data base is information on 128 houses sold in the 1960's and early 1970's in Durham, N.C. These data were supplemented by 1970 census data. Because of sparse data on neighborhood and public service variables, Wyse is not able to generate very believable demand and supply equations, particularly for fire safety. The results for home heating quality are more encouraging, although even there the specifications of the supply and demand curves are quite limited. Thus, from the standpoint of providing empirical evidence of the demand and supply functions for local public services, the Wyse paper is not very successful. However, the paper does develop the correct framework for making such empirical estimates. A better data base, for Durham or elsewhere, would enable Wyse to make a larger contribution to the empirical questions addressed by the Rosen framework.

There is a further limitation in the use that public policymakers can make of studies such as the one by Wyse. The major usefulness of empirical investigations of this sort, apart from their contribution to understanding the nature of price determination in urban housing markets, is to obtain estimates of the value that urban residents place on services provided by the public sector. These services can be either directly provided by the government (as in the case of fire protection) or can be provided indirectly by government policies to reduce disamenities (as in the case of air pollution control). By using price differentials in the urban housing market to assess the value of these government actions, even in a theoretically correct model such as the one used by Wyse, assumes that households accurately perceive differences in the quality of local public services and neighborhood amenities and disamenities between subareas of the city. If this assumption is incorrect, the procedure used by Wyse and others will not reveal the full value placed on improved public services and neighborhood amenities. Since the accuracy of that assumption is an empirical proposition, there is another important empirical obstacle to the use of these studies by policymakers. Ideally, housing value studies such as the Wyse paper would be supplemented by other methods of obtaining household preferences for nonmarketed products, such as interview and survey techniques.

MORLAN

The paper by Morlan, entitled "An Application of Microdata for Forecasting Aggregate State and Local Government Expenditures and Employment," is the most pragmatic. Its objective is to forecast the demand for State and local government services, expressed as expenditures and employment, broken down into current and capital outlays. The forecasts made by Morlan are in turn to be used as an element in an economy-wide input-output table developed by the Bureau of Labor Statistics. Morlan's empirical evidence consists of

demand functions for 47 disaggregated components of the State and local sector. These demand functions are estimated with data for the 50 States and the District of Columbia over 11 years. The State data include both State and local expenditures.

As in most forecasting models, the major difficulty is forecasting the independent variables. Although Morlan's estimated demand functions seemed plausible, even projections made 1- or 2-years beyond the 11 years showed a great deal of inaccuracy. The major difficulty was that the Federal government significantly altered its program of grants to States and local governments, instituting revenue sharing in place of categorical grants. Morlan also noted changes in the trends of school age population, and an increasing commitment on the part of government to environmental problems. Estimating shifts of these kinds, which reflect institutional changes at the Federal level as well as preference changes for local and State decisionmakers, is extremely difficult. Thus, those using the results of the Morlan model, or its extension through an input-output model for the entire economy, should be wary, particularly when projecting specific sectors.

Several more specific difficulties arise in using the Morlan results. As Morlan discusses in some detail, there are statistical difficulties associated with specifying the error term in estimating a model using a time series of cross sections. Income was found to be the most important variable explaining per capita expenditures. But since Morlan did not include a price term in his model, one cannot predict what State and local governments would do if the relative prices of various expenditure categories changed. In addition, since demand is measured by expenditures rather than output, one cannot determine the impact of changed technology on State and local expenditures. This problem of not being able to adequately measure quantity for government activities is, of course, common to all studies which use expenditure data. Another conceptual difficulty with the Morlan study is its aggregation of State and local expenditures. The decision units involved are in fact a large number of localities rather than the 50 States Morlan identifies. If one were attempting to understand the decisionmaking process that State and local government officials use to make expenditure decisions, a much more elaborate data base would be required. The aggregated State data that Morlan uses may be adequate for the forecasting objective, in the sense that disaggregating the data to local level would make the problem of projecting independent variables even more intractable. These limitations should be kept in mind in interpreting or using the results of the Morlan model.

PUBLIC POLICY IMPLICATIONS

My concluding comments summarize the public policy implications of the three papers. What public policy decisions might be improved, or perhaps better understood, as a result of the empirical contributions made by these three papers? The question is easiest to answer in the case of the Lee and Liu paper, because the authors directly confront policy issues. Lee and Liu's results indicate to local decisionmakers the impacts that their expenditure and taxing policies have on regional growth, although my comments on the paper suggest that the specific results reported in the paper should be used with caution. It is possible that the influence of local government expenditure and tax policy on employment and migration is quantitatively very small, in comparison to factors such as labor availability, proximity to markets, site and building availability, and financing arrangements. Moreover, since Lee and Liu do not consider differences within a single urban area, their results might shed relatively little light on what a single city or town within an urban area could do to affect its employment growth.

The Wyse paper promises to allow policymakers to make expenditure decisions which more accurately reflect the preferences of their constituents. If one could accurately estimate the willingness-to-pay of local residents for things such as fire protection, police protection, education and the like, it might be possible to determine those areas where expenditures should be increased or decreased. However, as my comments on the Wyse paper indicate, a good data base is required to determine, with any confidence, the value of government services using this technique.

The Morlan paper is the most removed from public policy, since its objective is primarily to forecast the future. However, a more accurate forecasting technique would allow users of the Bureau of Labor Statistics model to make more reasonable decisions. The usefulness of these results is likely to be greatest in those areas where adjustments require long time lapses, such as education. For example, if one could have predicted the decreased demand in school age population which occurred in the late 1960's and early 1970's, and the resulting decrease in demand for education, fewer teachers might have been trained. While many teachers have been able to find jobs in other sectors of the economy, it is clear that some of the expenditures for teacher training constituted a waste of society's resources. Whether models of the sort developed by the Bureau of Labor Statistics, for which Morlan's model is one component, would be of use in making these kinds of policy shifts is an empirical question.

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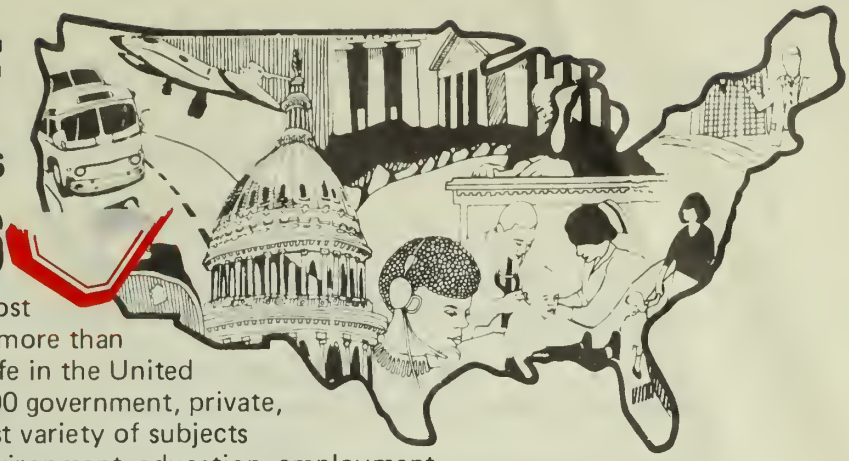

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